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ART. I.—*New Australian Tabanidæ, with Notes on Previously Described Species.*

BY E. W. FERGUSON, M.B., Ch.M.

(With Plates I., II., and 4 Text Figures.)

[Read 12th March, 1920.]

The material on which this paper is founded is derived from several sources. A number of the new species are from a collection of *Tabanidae* forwarded to me from the National Museum, Melbourne, for identification, others are from Mr. Hardy's collection, mainly Tasmanian, but including a few Western Australian forms, the remainder are from the collection of the Department of Public Health, New South Wales.

It was hoped when the paper was undertaken to have revised the whole of the species comprised in the hairy-eyed group of *Tabanus*, but the completion of this work would probably delay this paper unnecessarily, and it seems better that the descriptions of the new species should be published as soon as possible.

Most of the material under study being from the Southern portion of Australia, types that I regard as of Antarctic origin predominate. To my mind our Australian Tabanid fauna has been derived from two sources—(1) Malayan, from which come species belonging to *Corizoneura, Silvius* and *Tabanus* (excluding the hairy-eyed group); (2) Antarctic, from which source have probably been derived our Southern Tabanid fauna, including the genera *Diatomineura, Erephopsis, Pelecorrhynchus* and the hairy-eyed group of *Tabanus (Therioplectes)*.

The distinction between *Diatomineura* and *Erephopsis* is by no means constant, the two genera are merely separated on the point of distinction involved in the opening or closure of the first posterior cell. In many species of *Erephopsis* in which the cell is usually closed examples are readily found in which it is open. On the other hand this cell may be closed in individuals belonging to many species of *Diatomineura,* in which the cell is habitually open.

I am indebted to Miss Phyllis F. Clarke for the illustrations that accompany this paper.

SUBFAMILY PANGONINAE.

Pelecorrhynchus fusconiger, Walker.

List. Dipt. i., p. 192 (1848); Ricardo, Ann. Mag. Nat. Hist. (8), V, p 407 (1910).

A male in the National Museum from Buffalo Mountains, Victoria, differs from Miss Ricardo's description in having bright red hair at sides of thorax above wing roots In a specimen from Stradbroke Island, Queensland (collected by H. Hacker, kindly given me by G F Hill) these hair tufts are bright golden yellow. The thorax in the Victorian specimen is also browner in colour In both specimens there is a narrow grey line on each side of median area of thorax, in anterior half only in the Victorian specimen, in the Queensland specimen extending to posterior border, but widening out and becoming less distinct posteriorly.

Pelecorrhynchus fulvus, Ricardo

Ricardo, loc cit., p. 406.

Two pairs agreeing with Miss Ricardo's description have recently been given me by Mr H W. Davey, from Bright, Victoria

One of the females differs from the other in the deeper reddish tint of the russet colouring of thorax and abdomen, and in having the first abdominal segment dark reddish brown instead of unicolorous with the rest of the abdomen The differences are hardly specific The two males agree with the other female, though both are smaller. As the male does not appear to have been described I append a short description.

♂ Long —12.5 mm

Face, black with black hairs, cheeks with long white hairs. Eyes widely separated, the forehead as wide as in female. Thorax and scutellum as in female. Abdomen shining black, first segment with long grey pubescence, the remainder with depressed black pubescence, sides of segments with fringe of white hair tufts. Legs and wings as in female.

In one of the males there are a very few reddish hairs intermingled with the black pubescence.

Pelecorrhynchus claripennis, Ricardo.

Ricardo, loc. cit., p. 408.

Two females under examination appear to belong to this species. The front, however, is not narrowed to vertex, the

thorax is brown with suberect black hairs and with scattered depressed reddish pubescence; in one female there is a very fine greyish line present on each side of median area (the other specimen has the thorax discoloured); the breast has reddish, not black, hairs; the wings are faintly tinged grey. In other respects the specimens agree with Miss Ricardo's description.

Hab.:—Victoria, Warburton (J. E. Dixon, Dec., 1918; Spry, 15/12/18).

PELECORRHYNCHUS FLAVIPENNIS, n.sp. (Plate I)

A large black species with yellow submedian thoracic vittae, yellow wings spotted with brown, and bicolorous legs.

♂ Long.—17 mm.

Black Face clothed with dark grey tomentum and long black hairs, with a few whitish hairs below; beard white behind, black in front; palpi clothed with long black hairs. Antennae bright reddish yellow, the basal two joints black. Eyes barely touching in middle. Posterior surface of head clothed with dense white pubescence, the upper margin with black.

Thorax black with a conspicuous yellow line on each side of median area, and a very short, less conspicuous line above wing roots; pubescence black, with hoary white tufts of hairs behind wing roots, shoulders grey with black hairs, becoming hoary below; sides with dense hair tufts, black in front, hoary posteriorly beneath wing roots Scutellum black in centre, grey at sides, clothed with black pubescence and fringed with hoary white hairs at each side and with black in middle.

Abdomen shining black, with depressed black pubescence and long black hairs along lateral margins of segments. Venter shining black, lateral margins with hoary white hair tufts

Legs with femora black, tibiae and tarsi bright yellow Wings bright yellow with dark brown markings (1) along posterior border, extending to apex; (2) across base of discal cell, not reaching anterior margin but connected with (1); (3) at apex of discal cell connected with (1); (4) a single isolated spot above apex of discal cell on second longitudinal vein; (5) at apex, where there are three semi-confluent spots, connected with dark markings of posterior border.

♀ Long:—13 mm.

Face strongly protuberant, clothed with brown tomentum, with grey tomentum below, and a patch of yellowish tomentum on each side of middle above, with

long moderately dense black hairs. Palpi very short, with second joint black below, reddish yellow above, clothed with long black hairs, apex not pointed, with a rather deep concave depression above, set somewhat obliquely. Antennae as in male. Eyes rather widely separated; the forehead practically square, clothed with dark brown tomentum in centre, bordered on each side with yellow, set with black hairs; ocelli on a definite raised tubercle. Thorax and abdomen as in male. Legs and wings coloured as in male.

Hab.:—Victoria, Fern Tree Gully (F. Spry, 10/12/04); Launching Place (G. Coghill, 21/1/08).

Types in National Museum, Melbourne.

The length given for the female is probably an under-estimate, as the tip of the abdomen is bent to a considerable extent.

This species differs widely from all others known to me, with the exception of a species from the Blue Mountains, New South Wales This latter, a description of which is shortly to be published by Mr. G. H. Hardy, agrees with *P. flavipennis* in the coloration of the wings, but differs in the thorax and legs.

Erephopsis clelandi, n. sp.

Allied to *E. macroporum,* and with similarly marked wings, but differing in the palpi.

♀ Long:—11 mm.

Face and cheeks covered with brown tomentum with rather sparse black pubescence; beard white; palpi dark brown, second joint short, broad, bluntly pointed, deeply concave on outer surface; antennae dark reddish brown, basal joints lighter, clothed with grey tomentum and long black hairs. Forehead moderately wide, narrowed to vertex, clothed with brown tomentum and black pubescence, longer on vertex. Eyes with dense brown hairs.

Thorax, with four dark tomentose stripes separated by light grey ones, the two inner dark stripes brown, the outer ones black, clothed with semi-erect black pubescence, with straggly tufts of long white hairs above wing roots; shoulders grey with long black hairs; pleurae clothed with grey and brown tomentum, with long mostly white hair tufts. Scutellum, reddish brown in centre, black at sides, clothed with black pubescence.

Abdomen yellowish brown with dark median spots on first three segments, broader on other segments, clothed with dark decumbent pubescence, sides with creamy pubescence. Venter

light yellowish brown with semi-erect dark hairs and decumbent white pubescence.

Legs dark brown, anterior and intermediate tibiae and tarsi lighter yellowish brown.

Wings dark grey in cells, clear for a narrow zone along veins; stigma dark brown, conspicuous; short or rudimentary appendix present.

Hab.:—New South Wales, Narrabri (J. B. Cleland, 10/18).

Four specimens were taken around a well in Pilliga Scrub, 20 miles south-west of Narrabri, biting the horses.

In the coloration of the wings the species strongly resemble *E. macroporum*, Macq., but may be distinguished by the abdomen not uniformly dark reddish. It also differs from specimens from South Australia, which appear to be *E. macroporum*, Macq., in having the second joint of the palpi noticeably shorter, not longer, than the first.

Type presented to Australian Museum, Sydney

Erephopsis subcontigua, n. sp

Closely allied to *E. contigua*, Walk., but differing in palpi, antennae, abdomen and legs.

♀ Long:—14 mm.

Face clothed with brown tomentum, more yellowish brown on sides, with black pubescence and a few straggling creamy hairs, especially at sides; beard creamy Palpi dark reddish brown and clothed with black hairs along edges, second joint long, only moderately dilatate at base and ending in a long point, basal portion strongly grooved. Antennae reddish, basal joint blackish, with long black hairs above and creamy below, second joint lighter than third, with long black hairs longest above.

Forehead distinctly wider anteriorly than at vertex, clothed with brown tomentum, yellowish brown at sides, pubescence black, some long black hairs on vertex. Eyes hairy.

Thorax black clothed with dark brown tomentum, more greyish anteriorly, with feeble traces of grey submedian longitudinal lines, pubescence black, with some long mingled black and yellow hairs on lateral borders above wing roots and posteriorly, also a prominent tuft of creamy hairs just behind wing roots. Shoulders brown with black hairs. Sides with a prominent tuft of creamy hairs above and black hairs below. Scutellum black with scanty black hairs.

Abdomen shiny red with a median row of black spots, sometimes absent on third, and generally widening out on apical segments; lateral margins with long black hair, partly creamy on first and second segments, and forming a tuft of creamy hairs on each side of apex. Venter reddish, with scanty creamy depressed hairs. Legs, reddish brown, posterior tibiae darker than others, femora black. Wings dark grey, yellow along costal cell; basal cells, discal cell and basal part of first posterior cell clear, hyaline; a dark brown band across transverse veins at base of discal cell, and traces of a second at apex of discal cell, fading into grey of apex. no appendix; first posterior cell closed or feebly open.

Hab.:—New South Wales, Meldrum (near Armidale) (J. Raven, 28/12/17).

Compared with this species, *E. contigua* differs in the broader lighter palpi, in the lighter coloured basal antennal joints, in the general clothing much more yellowish, in the darker abdomen, in the lighter legs and in the much more heavily marked wings.

The coloration of the second antennal joint is variable; it is perhaps more usually black than yellowish.

Type presented to Australian Museum, Sydney.

Erephopsis ruponiger, n sp.

Allied to *E. lasiophthalma*, but with median abdominal spots united to form a continuous vitta on first three segments and expanding basally on other segments.

♀ Long:—12 mm.

Face and cheeks black with rather sparse grey tomentum and long grey pubescent hairs intermingled with black ones; beard dense creamy; palpi with second joint rather short, moderately dilated, pointed, strongly concave on outer surface, reddish yellow with intermingled grey and black hairs along upper and lower margins; antennae reddish, the third joint somewhat darker than first and second, which bear long black hairs. Forehead distinctly convergent towards vertex, black with brownish tomentum and long black hairs. Eyes densely hairy. Thorax dull black, subnitid where denuded, covered with dark brown tomentum, with long semi-erect black hairs, and with fine decumbent creamy hairs along anterior portion and forming feeble hair tufts above wing roots; shoulders with black hair tufts; sides with very dense creamy hair tufts; scutellum black with sparse creamy hairs on apical margin.

Abdomen reddish yellow, with a broad black median spot on first segment, continuing as a median vitta on the second and third segments, the remaining segments with broad transverse bands occupying the basal two-thirds; traces of creamy pubescence on segmentations; with rather dense lateral tufts, creamy on first and second and apical two segments and black above creamy beneath on the third, fourth and fifth. Venter lighter reddish yellow with sparse yellowish pubescence.

Legs light reddish yellow; tarsi infuscate, black at apices.

Wings clear, tips faintly tinged grey, costal margin, the extreme base of wing, and cross vein at base of discal cell suffused with brown; stigma inconspicuous; no appendix present; first posterior cell usually closed, open in type specimen.

Hab.:—New South Wales, Armidale (J. Ravin), Deervale.

Close to *E. lasiophthalma* the present species may be distinguished by the continuous abdominal vitta; from *E. subcontigua,* it differs in smaller size, lighter coloured wings, lighter legs, shorter palpi, etc

Erephopsis xanthopilis, n. sp.

A distinctively marked black and red species with golden hair tufts and yellow anterior margin to wings; evidently allied to *E. jacksoni,* Macq.

Long:—13 mm.

Face rather strongly convex separated from cheeks by deep grooves, testaceous, with grey tomentum, and a few sparse black hairs, cheeks black with yellowish grey tomentum and golden pubescence; beard golden. Palpi reddish yellow, with second joint broad and produced into a rather long point, moderately deeply concave on outer surface, set with rather short somewhat sparse black hairs. Proboscis long, black. Antennae bright reddish yellow, the basal joints rather lighter in colour, the first with black hairs above, creamy below, the second with a circlet of long black hairs Forehead distinctly narrowed to vertex, black clothed with yellowish brown tomentum and erect rather short black pubescence. Eyes clothed with light coloured hair.

Thorax black, clothed with blackish tomentum, and set with erect black hairs and scattered decumbent golden pubescence; with rather sparse golden hair tufts above wing roots; shoulders with black hairs and decumbent golden pubescence; sides and breast with prominent golden hair tufts; scutellum black with golden pubescent hairs at apex.

Abdomen bicolorous; first segment reddish narrowly margined with black along the edge of the scutellum, second reddish with a conspicuous median vitta from base to apex, remaining segments black; pubescence black with a series of creamy median triangular spots on the posterior margins of the second to sixth segments; lateral margins with creamy hair tufts on the second and apical segments and black overlying creamy tufts on intervening segments. Venter reddish yellow with rather scanty fine decumbent black and light hairs. Legs reddish yellow with basal half of femora black, posterior tibiae darker and tarsi infuscate.

Wings light grey, the anterior margin and base tinged yellow, the base of discal cell and cross veins above lightly suffused with brown; stigma inconspicuous, veins yellowish or light brown; no appendix; first posterior cell closed.

Hab :—New South Wales, Hawkesbury River (29/11/13), Dorrigo (Feb., 1918), Comboyne (3/12/17); Victoria, Bright (H W Davey).

I have had this species for some time queried as *E. jacksoni;* on a recent visit to the British Museum it appeared to me to be different from the species so identified in that collection; subsequently a specimen was sent home for comparison with the specimens of *E. jacksoni,* and has been returned as "*Erephopsis sp.*, not in British Museum." Under the circumstances I have decided to give the species a new name as specimens are in various Australian Museums, and require an appellation, and because I feel confident that I know the true *E. jacksoni*, Macq.

The amount of shading on the cross veins varies; it is always rather faint and generally more yellow than brown, and in some specimens is almost evanescent. The Victorian specimens lack the white spots on the abdomen, but this may be due to abrasion.

Type presented to Australian Museum, Sydney.

Parasilvius, n. g.

Ocelli and spurs on hind tibiae present. Face protuberant; palpi very short, first joint round, with undersurface convex, second joint short subcylindrical; antennae with first joint short about twice as long as second, third joint broad at base then subulate, with five distinct subdivisions and evidences, most marked in ♀, of three further subdivisions.

Forehead broad and concave in ♂; eyes feebly pubescent in ♀; evidently so in ♂; wings with posterior cells all widely open, anal cell closed.

This genus is proposed for a species from Victoria which cannot be referred to any of the previously described ones. The ♀ has a broad, irregularly grooved forehead very reminiscent of *Ectenopsis*, but the palpi are very different, and the whole insect has a broader facies. The antennae might be regarded as having the third joint, five or eight segmented; in the type ♀, under the microscope (and to a less extent with a hand lens) the apex of the basal portion of the third joint appears very indistinctly divided into three annuli; in the other ♀, this subdivision is still more distinct, while in the ♂ this portion of the joint appears unsegmented. It seems to me that the genus is one in which the antennae are in process of being converted from an eight annulate third joint to a five annulate, by a process of fusion of the four basal annuli.

Regarding the third joint as five annulate the genus may be distinguished from *Silvius* by the shape of the palpi. If the third joint be regarded as eight annulate the genus would fall in the same group as *Ectenopsis* and *Demoplatus;* from all the members of which, excepting possibly *Palimmecomyia;* the genus may be separated by its hairy eyes and short palpi. I do not think this genus can be the same as *Palimmecomyia,* as judging from the description the antennae are different, and apparently have a distinctly eight annulate third joint.

PARASILVIUS FULVUS, n.sp.

♀ Long:—11 mm., a second ♀ 15 mm

Face protuberant, bounded on each side by deep grooves, bright yellow with fine scanty pubescence; beard yellow; palpi very short, yellow, first joint briefly oval almost rounded in outline, the lower surface convex, clothed with long yellow hairs, second joint short, slender, subcylindrical, ending in a blunt point, with short black hairs most thickly set at apex; proboscis of moderate length, slightly longer than head; antennae reddish yellow, the first two joints paler, annuli black at tip, first two joints with a few black hairs at apices, third joint transverse subquadrate at base, thence subulate, with very indistinct traces of three annulations followed by four distinct annuli. Forehead irregularly grooved on each side of middle, distinctly wider anteriorly than at vertex, yellow, clothed with yellow tomentum and extremely scanty pubescence; ocelli conspicuous with some black hairs, on ocellary triangle; eyes with very short hairs, facets equal. Thorax deep brown, shoulders yellow; clothed with

yellow tomentum and with erect yellow pubescence mingled with darker hairs, especially in middle, with tufts of golden hairs above and behind wing roots; shoulders and pleurae with golden hairs; scutellum similar to dorsum, fringed with golden hairs.

Abdomen flat, broad, dark tawny, first segment black in middle and lighter reddish yellow at sides; clothed with short decumbent black pubescence, with longer black hairs along each side and at apex, base and sides of first segment with yellow hairs; venter reddish yellow, with fine yellow pubescence.

Legs reddish yellow, posterior tibiae darker, femoral pubescence yellow, elsewhere dark.

Wings tinged grey, costal cell and extreme base yellow, stigma brownish yellow, inconspicuous, an appendix present.

♂ Long:—10 mm.

Face densely covered with yellow tomentum and long yellow pubescence; palpi short, first joint rounded, convex on lower surface clothed with long yellow hair, second short subcylindrical, rather stout, with black and yellow hairs. Antennae similar to ♀ but apex of basal portion of third joint apparently non-segmented. Eyes contiguous, hairy. Thorax clothed with long brown hairs and with dense tufts of golden yellow hairs at sides, posterior border and posterior margin of scutellum with long yellow hair.

Abdomen shorter than in ♀, first segment black, with basal black spot on second segment, the whole densely clothed with long black hairs, sides of segments with long yellow hairs; venter with long yellow and black hairs intermingled. Legs and wings as in ♀.

Hab :—Victoria, Sea Lake (J C. Goudie, Nov.-Dec., 1916). Described from 2 ♀♀ and 1 ♂. The second ♀ is larger than the type, and the yellow hairs on thorax do not extend to middle, which is clothed with the darker hairs; the abdomen is lighter tawny colour, but it is possible that this specimen is in better preservation; the other was selected as type, as it corresponds more closely with the male in size and general appearance.

Types in National Museum, Melbourne.

ECTENOPSIS VULPECULA, Weid.

Weid. Ausszweifl. Ins., 1, p. 195 (Chrysops) (1828); Ricardo, Ann. Mag. Nat. Hist. (8), XVI., p. 266 (1915); Taylor, Records Australian Museum, XII., 5, p. 63 (1918).

Miss Ricardo has recorded the synonymy of *Pangonia angusta*, Macq., *Corizoneura angusta*, Bigot and *C. rubiginosa*, Bigot, with

E. vulpecula, Weid., the type species of the genus. While the above three species are undoubtedly the same it seems to me questionable whether they are really synonymous with *E. vulpecula,* Weid.

I have not seen Weidemann's original description, but apparently the name was applied to a species with black legs. I have taken a species at Sydney which has the legs, except the coxae deep black, the wings are also smoky, almost deep black in fresh specimens, but fading somewhat with age, the palpi variable in colour, black to testaceous. Compared with this, which corresponds closely with *E. vulpecula,* Weid., *var. nigripennis,* Taylor, are specimens in which the legs are yellowish (testaceous) and the wings clear, the stigma being inconspicuous in marked contrast to the black of the stigma in the other form. While I recognise that the species may prove sufficiently variable to include the two forms, I think that at any rate varietal names should be given to each. *E. vulpecula,* Weid., evidently from all the evidence, should be applied to the black legged form, and I would regard the *var nigripennis,* Taylor, as a synonym. I have found this form during two seasons on the flowers of *Bursaria spinosa.*

E. angusta, Macq. (= *E. angusta,* Bigot and *E. rubiginosa,* Big.), would apply to the paler legged form. I am indebted to Dr. Guy A. K. Marshall for the following particulars of these species:—

"*Ectenopsis angusta,* Macq. (3 ♂♂), and *E. rubiginosa,* Big. (1 ♂) seem certainly the same, all femora dull testaceous (like the abdomen); anterior pairs of tibiae similar but slightly infuscated at apex, hind pair infuscated throughout; tarsi blackish, anterior pair paler at base.

"*E. angusta,* Big. (1 ♀). Femora testaceous yellow; tibiae very slightly darker; tarsi infuscated, paler at base."

Ectenopsis (?) minor, Taylor.

Silvius minor, Taylor, Records Australian Museum, XII., 5, p. 62 (1918).

I have examined the type of this species, and am strongly of the opinion that it cannot be retained in *Silvius.* Mr. Taylor kindly re-examined the type at my request, and agrees with me that the antennae are much more of the Ectenopsis type. The number of annulations of the third joint are extremely difficult to make out, but six subdivisions can be seen while the apical

portion representing the last three joints in *Ectenopsis* appears unsegmented. Probably a new genus may have to be erected for the species, but the general facies is so like *Ectenopsis* that I do not think it advisable to do so in the present state of our information on this genus.

ECTENOPSIS AUSTRALIS, Ric.

Ricardo, Ann, Mag. Nat. Hist. (8), XIX., p. 217 (1917); Taylor, Records Australian Museum, XII., 5, p. 63, (1918).

Miss Ricardo is incorrect in her statement as to the location of the types—the male type is in the British Museum, not the female, as stated by Miss Ricardo; the latter is at present in my possession, but it is intended to present it, with other types, to the Australian Museum, Sydney.

Mr. Taylor's descriptive notes do not apply to this species. I have examined the specimens in the Australian Museum, and they are certainly not *E. australis*, Ric. The female type measures 10.5 mm. in length.

ECTENOPSIS (?) VICTORIENSIS, sp. n.

A dark brown species with long body and comparatively short wings, doubtfully assigned to this genus.

Long:—14 mm., width across head 3.5 mm, wing 11 mm.

Face protuberant with very deep sulci on each side, yellow-brown clothed with grey tomentum and scanty grey pubescence; beard scanty grey; palpi yellow, first joint very short subcylindrical, clothed beneath with long grey hairs; second joint slender, at least twice as long as first, curved, slightly constricted at base, and ending in a fine point, clothed with short dark hairs; antennae with first two joints yellowish-brown, tipped with black hairs, the third joint with small quadrate basal portion and first three annuli which are small and indistinct, reddish yellow, and the remaining annuli black and much more distinct. Forehead light brown covered with grey tomentum, and some black hairs on ocelligerous triangle; concave anteriorly, and about twice as wide as it is at vertex. Eyes bare, facets equal. Thorax deep brown, clothed with brown tomentum and with traces of yellow brown tomentum forming an indistinct stripe on each side of median area; with semi-erect dark hairs anteriorly and long scanty decumbent grey pubescence posteriorly, and above wing roots, sides with scanty grey pubescence, scutellum similar with a fringe of scanty grey hairs.

Abdomen dark brown, segmentations yellowish brown; first segment with grey pubescence, remainder with short decumbent dark pubescence, and a fringe of yellowish brown hairs on segmentations; venter similar, segmentations rather broader. Legs light yellowish brown, the posterior pair rather darker, tibiae slightly darker at apices; tarsi brown; long spurs present on posterior tibiae.

Wings, grey, yellowish brown along the anterior border; veins brown, stigma brown, appendix present, all the posterior cells open.

Hab.:—Victoria, Mallee District.

Described from a single female sent by the National Museum, Victoria. I have referred this species to *Ectenopsis* with a good deal of hesitation, the antennae are very similar to those of *Parasilvius*, and the basal divisions of the third joint are very indistinct. The palpi are, however, different, and more like those of *Ectenopsis*, though shorter and more slender. Probably a new genus will ultimately have to be erected for its reception, but I am unwilling to do so at present on a single female. The coloration will readily prevent any confusion with the described species of *Ectenopsis*.

Type in National Museum, Victoria.

Since the above description and notes were written, I have received for examination two males belonging to the South Australian Museum, which appear to me to belong to the same species as the Victorian female. There are some differences which may, however, be sexual, and the specimens are certainly too like *E. victoriensis* to be described as distinct, at least until a South Australian female can be obtained.

Following is a short description of the males in so far as they differ from the type female.

♂ Long:—10-12 mm.

Colour and clothing as in female; eyes contiguous, bare, facets equal; ocelli distinct. Facial triangle reddish brown, clothed with grey tomentum and with long bristle-like hairs, first joint short and stouter than second; second short and ending in short point, shorter and stouter than in female; antennae rather more slender than in ♀ and with apical annulus only dark, the third joint with five distinct annuli and indistinct evidence of two further subdivisions, the apex of antennae with a group of short hairs

Thorax dark brown with evidences of three indistinct greyish tomentose stripes, clothed with upright brown hairs, sides with

tufts of long pubescence, mostly creamy, brown in centre; scutellum reddish brown.

Abdomen, narrower than in female, dark brown, segmentations lighter, clothing abraded.

Legs and wings as in female.

Hab.:—South Australia, Denial Bay, Murray River.

SILVIUS SULCIFRONS, n. sp.

A black medium sized species, forehead with median line depressed, sulciform; wings clouded on veins.

♀ Long:—12 mm., width of head 4 mm., wing 11 mm.

Face and cheeks clothed with grey tomentum and rather sparse black pubescence, a few white hairs in groove between face and cheeks; beard white, palpi dark reddish, clothed with short black pubescence, second joint long, nearly equal to proboscis, slightly curved; moderately stout at base, apex truncated; antennae with first joint rather long, black, clothed with grey tomentum and black pubescence, second joint much shorter, reddish, with circlets of black hairs, third joint reddish, annuli black, base broad with a very strong tooth projecting forwards; subcallus not strongly tumid nor shiny, densely clothed with grey tomentum and with short black pubescence. Forehead comparatively narrow, subparallel, densely clothed with brownish tomentum, with scattered black pubescence; a short linear callus anteriorly followed by a depressed sulciform line extending to ocellary triangle; ocelli present; eyes hairy.

Thorax black, tomentum dusky, with faint traces of a submedian grey line on each side anteriorly; pubescence black, a few grey hairs posteriorly and at sides; shoulders dark, with reddish tinge, clothed with long black pubescence, sides black with grey tomentum and tufts of long hair mixed with black and hoary grey. Scutellum black with scanty grey hairs along posterior margin.

Abdomen black, segmentations reddish brown; with decumbent black pubescence and apical triangular white flecks on second, third and fourth segments, first four segments also with posterior margin fringed near sides with white pubescence.

Legs dark, femora black with yellow knees, tibiae and tarsi reddish brown; posterior tibial spurs rather long and distinct.

Wings with veins faintly margined with brown; most distinct along anterior border and on cross veins.

Hab.:—West Australia, Perth (G. H. Hardy).

Four specimens under examination. The species is somewhat variable in the coloration of the abdomen, in one specimen the segmentations are broader and more reddish, while in another the third and fourth segments are almost wholly reddish, while the black on the second is reduced to a large median spot; the wings in these two are also more heavily shaded with brown, and the palpi more dusky. As in other respects these agree with the type, I cannot separate them specifically.

The species should be readily recognised by the frontal structure; the hairy eyes will also distinguish from most described Australian species of *Silvius.*

The type has been kindly presented to the Australian Museum, Sydney, by Mr. G. H. Hardy.

Silvius nigroapicalis, n. sp.

A dark winged species allied to *S. nigripennis*, Ric., but with basal two-thirds of abdomen bright yellow.

♂ Long:—12 mm., width across head 4 mm., wing 10.5 mm.

Face clothed with bright golden yellow tomentum and similar coloured pubescence; beard golden yellow; palpi black clothed with short black hairs, first joint short and narrow, second joint rather stout, broader than first and about three times as long; antennae black, first two joints with black hairs, third joint broad and angulate above at base, annuli indistinctly divided. Subcallus not protuberent, densely clothed with golden yellow tomentum. Eyes contiguous, bare, facets equal; ocelli present.

Thorax black, clothed with dense black pubescence; shoulders and pleurae clothed with dense tufts of long golden yellow hairs; scutellum black with black pubescence.

Abdomen with first three segments golden yellow, with rather scanty golden pubescence along the posterior margins, remaining segments black with black pubescence; venter with same alternation of colour, golden pubescence on basal segments rather more dense. Legs black. Wings tinged dark sooty grey, almost black, slightly paler in centre of cells and at extreme tip; no appendix present.

Hab.:—North Queensland, Claudie R. (J. A. Kershaw, 16/1/14).

The species, of which I have two males before me, is allied to *S. nigripennis*, Ric., from the same locality. The differences in the clothing of head and thorax and in the coloration of the abdomen are too great for me to consider that it is the male of

S. nigripennis, though the coloration of the wings is exactly as in that species.

Type in National Museum, Melbourne.

SUB-FAMILY TABANINAE.

Tabanus.

Group XI.—Therioplectes. Eyes Hairy.

TABANUS CIRCUMDATUS, Walker.

List, Dipt. I., p. 185 (1848); Ricardo, Ann. Mag. Nat. Hist. (8), XVI., p. 280 (1915).

Synonyms: *T. nepos*, Walk., *T. abstersus*, Walk., *T. brevidentatus*, Macq., *T. hebes*, Walk.

Considerable confusion still exists between the three allied species, *T. circumdatus*, Walk., *T. antecedens*, Walk., and *T. edentulus*, Macq. As the result of the study of a considerable amount of material from Tasmania and the southern portion of Australia, I had hoped to be in a position to state definitely what were to be regarded as the differential features separating them. For various reasons, it appears desirable to postpone a detailed discussion of this question, and I have limited my remarks to a purely preliminary note on each species.

The chief difficulty confronting any worker on this difficult group (Therioplectes) is the variability of some of the species. In this respect, *T. circumdatus* is extremely difficult to define; at present I regard it as distinct from *T. edentulus*, but many forms occur which might with almost equal justice be referred to either species, or in some instances justify their erection into distinct species.

In Tasmania occur three closely allied forms, one certainly *T. circumdatus*, another identified by White as *T. edentulus*, and apparently always distinguishable from *T. circumdatus* by the noticeably different antennae, and the third a larger species provisionally identified as *T. acutipalpis*, Macq. *T. antecedens* is readily distinguished from all three and appears to be restricted, as far as my observations go, to Tasmania.

On the mainland occur variable forms of both *T. circumdatus* and *T. edentulus*, some of which tend to link up the two species.

Miss Ricardo, besides giving the above synonymy, notes the possible synonymy of *T. edentulus*, *T. acutipalpis*, and *T. fraterculus*, Macq., with *T. circumdatus*. I have no knowledge of *T. fraterculus*, Macq.

TABANUS EDENTULUS, Macq. (Plate II., fig. 5).

Macquart, Dipt. Exot. Supp. i., 34, 68, Tab. iii., fig. 13 (1845); White, Papers and Proc. Roy. Soc. Tasmania, p. 10 (1915).

Mr. White has attached Macquart's name to a species closely allied to *T. circumdatus*, but I do not know what is his authority for the identification. While in Paris I examined a number of Macquart's Australian Tabanidae, and have the following brief note on this species:—

"'*T. edentulus*, Macq., n. sp.' So marked in Macquart's handwriting, has the eyes densely covered with white silky pubescence, otherwise it is a dark species. I think it is *antecedens* according to White."

I do not now remember my authority for ascribing the handwriting to Macquart; probably my informant was M. Lesne, who was so kind as to show me the specimens. I cannot be certain that the specimen examined was actually the type, as there was no type label. Pending further enquiries I do not propose to sink *T. antecedens*, Walker, under *T. edentulus*, Macq.

The species identified by White as *T. edentulus* is certainly distinct from *T. antecedens*, Walker, but for the present I have left the species under Macquart's name. White's paper may be referred to for a full description.

Typical specimens differ from *T. circumdatus* in the noticeably more slender third joint of the antennae; as a rule, it is a smaller, darker species than *T. circumdatus*, but is variable both in size and colour.

Further discussion of the variations, both of this species and *T. circumdatus* is postponed for the present.

TABANUS ACUTIPALPIS, Macquart

Macquart, Dipt. Exot. 1, p. 131 (1838).

Specimens of a large species allied to *T. circumdatus* are before me; they agree with specimens in the British Museum doubtfully labelled *T. acutipalpis*, Macq.

While in Paris I made the following note on specimens labelled *T. acutipalpis*:—

"*T. acutipalpis*, Macq., Tasmania, seems to me certainly *T. circumdatus*. Nine specimens, with at least two with labels in Macquart's handwriting."

Miss Ricardo's notes under *T. circumdatus*: "*Tabanus acutipalpis*, Macq., appears very similar, but is larger in size."

As most of the Tasmanian specimens of *T. circumdatus* are larger than the mainland ones, I think it is likely that this synonymy will be found correct; at present, however, I am not quite certain, as I am not sure I saw the type, and as I did not have undoubted specimens of *T. circumdatus* with me for comparison. For the present, therefore, I do not intend to describe the specimens alluded to above which are certainly distinct from *T. circumdatus.* They represent a species which seems confined to Tasmania, Flinders Island (probably other islands of Bass Strait), and the neighbouring portion of Victoria.

Macquart gives the locality as follows:—De l'ile King, dans l'Oceanie. M Durville. Museum. Is it possible that King Island in Bass Strait was intended?

TABANUS ANTECEDENS, Walker (Plate II, fig. 3)

Walker ♂ List. Dipt. i., p. 178 (1848); ♀ List. Dipt. V., p. 253 (1854); Ricardo, Ann. Mag. Nat. Hist. (8), XVI., p. 279 (1915); White, Roy. Soc. of Tasmania, Papers and Proc., p. 9 (1915).

There can be no doubt from the description given by Miss Ricardo of Walker's type, female, that White is correct in identifying it with a common Tasmanian species allied to, but distinct from, both *T. circumdatus,* Walk., and the species generally known as *T. edentulus,* Macq

By a curious error, however, Miss Ricardo has reversed the references given for the sexes, the male having been described first in 1848.

Referring to the male, Miss Ricardo gives the following note: —"The male type of *Tabanus antecedens* comes from New Holland (Hunter), and the antennae are imperfect; whether it is really the male of the above is doubtful." This opens up the question as to the correct assignation of the name to the female, which is further complicated by the possibility that the name *T. edentulus,* Macq., should belong of rights to the species under review and not to the one usually identified under this name.

Pending further information I am content to leave the names as at present utilised. Thus understood *T. antecedens* may be distinguished from *T. edentulus,* Macq. and *T. circumdatus,* Walk., by the pubescence on the eyes noticeably longer and denser and white in colour, and by the more densely hairy front.

In these respects it is nearer *T. latifrons,* sp. n., but the wider forehead will distinguish that species.

TABANUS LATIFRONS, n. sp. (Plate II., Fig. 1).

Allied to *T. antecedens*, Walk., but with broader forehead.

♂ Long:—12 mm.; width of head 5 mm.; wing 10.5 mm.; ♀ Long:—13 mm.; width of head 5 mm.

♀ Black; face, cheeks and subcallus black, reddish brown above proboscis, densely clothed with white tomentum, and with long pubescence, white below, dark above and on subcallus, the latter not markedly tumid nor shining. Palpi dusky, lighter at apex, moderately thickened at base, with dark grey tomentum and mixed pale and dark pubescence, long and somewhat straggling at base, shorter at apex. Antennae black, first and second joints grey, and clothed with long dark hair like pubescence, third joint broad at base, prominently angulate above, annuli somewhat shorter than basal portion. Forehead very broad anteriorly, distinctly narrowed to vertex, about twice as long as it is wide anteriorly; densely clothed with dark brown tomentum, slightly variegated with grey, and with long dense dark hairs, longest and most dense at the vertex; callus transverse or subquaderate, reaching eyes without lineal extension, black. Eyes densely pubescent, the pubescence long, light brown with grey reflections from certain directions. Thorax black, shoulders reddish, densely clothed with black tomentum with a narrow indistinct grey tomentose stripe on each side of median area most evident anteriorly, and two indistinct lateral stripes most distinct posteriorly; dorsum densely clothed with long erect black pubescence, and with scattered white decumbent pubescence, most distinct posteriorly. Sides black with long pubescence, mostly white, but dark in centre. Scutellum black, fringed on each side with long white pubescence.

Abdomen subparallel, black, segmentations dark grey, hardly lighter than rest of dorsum, densely clothed with semi-erect black pubescence, with small white pubescent spots on all segments except first, most distinct on 2-5; the lateral and postero-lateral margins of segments from the second also fringed with white pubescent hairs. Venter black with dark grey tomentum, and densely clothed with long erect black hairs, posterior margins of segments with short depressed white pubescence.

Legs dark, femora black, tibiae dark reddish brown, the intermediate lighter in colour, and the anterior black at apex; tarsi black; femoral pubescence mostly dark, pubescence on posterior tibiae irregular as in *T. antecedens*.

Wings, hyaline, veins and stigma black; appendix present, always short, sometimes rudimentary.

♂ Eyes contiguous, very densely hairy, facets apparently uniform in size. Antennae with third joint less expanded at base, first and second joints very hirsute.

Palpi yellowish brown, second joint oatshaped, densely pubescent.

Thorax similar to ♀. Abdomen much more strongly narrowed to apex, black sides of first and second segments reddish brown, clothing as in ♀.

Legs and wings as in ♀.

The female differs from *T. antecedens* female in the wider front, which is also more hirsute, the basal antennial joints are also much more hirsute. In general it is darker in colouration than *T. antecedens*, of which it may represent a mountain race.

Hab.:—Cradle Mountain, Tasmania (G. H. Hardy, Jan., 1917), 1♂, 7 ♀♀. Two females from Mount Wellington and one female from Maria Island apparently belong also to this species, but differ in having the second abdominal segment reddish brown towards sides, with lighter anterior margin (in *T. latifrons* the anterior margin of second segment is dark greyish), the other segmentations also are obscure reddish grey, instead of dark grey.

In some specimens the first and second joints of antennae are black. A further long series of this species from Cradle Mountain, collected by Messrs. A. M. Lea and H. J. Carter, is in the South Australian Museum collection. Types presented to Australian Museum, Sydney, by Mr. G. H. Hardy.

TABANUS TASMANICUS, n. sp. (Plate II, Fig 2)

A medium sized dark species, resembling *T. edentulus* in appearance, but with frontal callus not reaching eyes.

♀ Long, 13 mm., width across head 4.5 mm., wings 11 mm. Face and cheeks densely covered with grey, almost white tomentum, and with scattered black pubescence, a few white hairs at sides of face; beard white, with a few intermingled dark hairs. Palpi slender, somewhat thickened at base, cream coloured, clothed with scattered mingled dark and pale hairs, longer at base. Antennae reddish brown, the third joint darker, first and second joints with moderately short black hairs; third joint not greatly expanded at base, angle small but distinct, annuli longer than basal portion. Subcallus black, densely clothed with grey

tomentum. Forehead wider anteriorly, about three times as long as broad anteriorly; clothed with grey tomentum, blackish in middle, and with moderately sparse dark hairs; callus black shining, small transverse, not reaching eyes, with short linear extension. Eyes with moderately dense short brown pubescence, width across eyes less than the width of abdomen.

Thorax black, covered with grey tomentum, leaving three indistinct black lines, one median and two lateral, a short black line also traceable on each side above wing roots; pubescence white, scattered; long dark erect hairs also present, most numerous anteriorly; shoulders grey; sides grey with long white hairs. Scutellum black with grey border, and with a fringe of long rather scanty white hairs.

Abdomen dark brown, first segment almost black, base of second segment and the segmentations rather broadly margined with grey; pubescence dark on basal portions, creamy white along segmentations, the white hairs thickest at sides, and on a series of apical median spots forming a more or less continuous median stripe. Venter yellowish, darker at base of segments, with long black semi-erect hairs and with finer decumbent creamy hairs most marked on segmentations

Legs yellow, femora dark brown, almost black, with yellow knees; tarsi infuscate, especially the anterior; pubescence on posterior tibiae rather straggling and irregular.

Wings hyaline, the veins very faintly margined with light brown, slightly more distinct on cross veins; stigma and veins brown, long appendix present

Hab.:—Tasmania, Dunally (seven specimens); Bream Creek (two specimens). Collected by G. H. Hardy.

Dates of collection, Dunally, 9-15/2/18; Bream Creek, 18-20/2/18.

The coloration of the thorax varies somewhat, and might be better described in the Bream Creek specimens as black, with more or less distinct grey lines; most of the specimens have, however, the thorax as described, though greyish lines are traceable between the black stripes.

The head is small as compared for example with specimens of *T. edentulus* of the same size. The size is also variable, ranging from 9.5 to 13 mm.

I do not know of any previously described species with which this can be confused.

Type presented to Australian Museum, Sydney, by Mr. G. H. Hardy.

TABANUS BASSII, sp. n. (Plate II., Fig. 4).

A small dark species with elongate frontal callus, not reaching the eyes.

♀ Long, 10 mm., width across head 4 mm., wing 9 mm.

Face black, densely covered with yellowish grey tomentum, and with long dark pubescence intermixed with a few sparse yellowish hairs; beard creamy. Palpi slender, little thickened at base, pale yellowish brown, clothed with cream pubescence below and with dark hairs above. Antennae black, first joint with a few sparse black hairs, third joint rather strongly widened at base, angulate above, annuli as long as rest of joint. Subcallus black, shining where denuded, clothed with dense yellowish grey tomentum. Forehead moderately narrow, very slightly narrowed at vertex, clothed with dense dark grey tomentum, with a distinct yellowish tinge, and with short black pubescence longer on vertex; callus elongate, narrow, about one-third width of forehead, tapering above, and with a lineal extension to middle. Eyes clothed with dense brownish pubescence.

Thorax black, shoulders grey, with rather sparse pale creamy decumbent pubescence, and longer erect black hairs; sides posteriorly, with tufts of creamy pubescence; shoulders with long black hairs; pleurae dark grey, with intermixed creamy brown pubescence Scutellum black, grey at sides, fringed with long pale creamy pubescence

Abdomen black, first segment brownish yellow at sides, second segment brownish yellow at sides and along each margin, segmentations margined with same colour; clothed with decumbent black pubescence, the segmentations with creamy, almost pale golden pubescence, dilated to form a series of median triangular spots on the segments. Venter black, with lighter segmentations, covered with yellowish grey tomentum, and with creamy pubescence most dense on the segmentations.

Legs with femora black, tibiae reddish brown, the anterior darker at apex, and tarsi dark reddish brown, the anterior black femoral pubescence long, creamy, posterior tibial fringe rather short, regular, black, a few pale hairs intermingled.

Wings hyaline, veins brown, very faintly margined with light brown, stigma brown, conspicuous; appendix present.

Hab.:—Victoria, Wilson's Prom. (Prof. Sir Baldwin Spencer); Macedon (J. E. Dixon, 17/2/17); Gippsland, Forrest (H. W. Davey); Tasmania, Wynyard (G. H. Hardy).

This species may be distinguished from its nearest congeners, *T. tasmanicus* and *T. dixoni*, by the frontal callus; the forehead is also very much narrower than in *T. dixoni*. The shading of the wing veins varies considerably, and in some specimens the wings appear quite hyaline.

Type in National Museum, Melbourne.

TABANUS DIXONI, n. sp. (Plate II., Fig. 6).

A small species allied to *T. postponens*, but with much broader forehead.

♀ Long, 10.5 mm, width across head 4.5 mm., wing 9.5 mm. Face and cheeks light reddish yellow, covered with grey tomentum and with scanty whitish pubescence; beard white. Palpi slender, a little stouter at base, yellow with long white pubescence at base, and a few short dark hairs elsewhere. Antennae with first two joints yellow, broadly dilated and angulate above; annuli black about as long as basal portion. Subcallus yellowish brown or reddish yellow, much denuded, in other specimens covered with grey tomentum. Forehead broad, hardly more than twice as long as wide, parallel sided; reddish yellow, clothed with grey or yellowish grey tomentum, and with scattered short black hairs; callus reddish yellow, small, inconspicuous, about one-third the width of front, tapering to a point, and with a lineal extension to middle. Eyes with rather short, fine pubescence.

Thorax black, shoulders reddish grey, clothed with grey tomentum, leaving indistinct indications of three black stripes separated by grey lines; with sparse decumbent golden pubescence and long erect black hairs, with scanty tufts of grey hairs above wing roots; shoulders with long dark hairs; sides reddish grey with long grey pubescence. Scutellum black with grey tomentum. Abdomen black, segmentations pale grey, dilated in centre to form a row of triangular spots on segments two to six, second segment bordered with grey at base; pubescence decumbent black, pale creamy on segmentations and on the median spots. Venter pale reddish yellow, somewhat darker at apex, clothed with grey tomentum with scanty short dark hairs, intermingled with creamy ones.

Legs pale reddish yellow, anterior tarsi black, the others dark reddish brown; femoral pubescence pale, posterior tibiae with rather sparse brown hairs. Wings clear, costal cell pale brown, veins brown, stigma brown distinct, appendix present.

Hab.:—Victoria, Lake Hattah (near Murray River), (J. E. Dixon, Nov., 1918); Mallee (J. E. Dixon, October, 1918).

The callus in this species is inconspicuous, being little raised and of the same colour as the frontal derm.

Mr. Dixon informs me that the eyes are brilliant green in life.

From *T. postponens*, Walk., it differs in its much darker coloration and wider front. The difference in the forehead, coloration of callus, antennae, legs, etc., will differentiate it from *T. bassii*, sp. n.

The Mallee specimen is larger than the type, measuring 13 mm.

Type in National Museum, Melbourne.

TABANUS REGIS-GEORGII, Macq (Text figures, 1a, 2).

Macquart, Dipt Exot, 1, p 132 (1838); Ricardo, Ann Mag. Nat. Hist. (8), XVI., p. 276 (1915); *T. brisbanensis*, Taylor, Proc Linn Soc. New South Wales, XLII., 3, p 526 (1917); id, XLIV., 1, p. 67 (1919).

I am indebted to the authorities of the Queensland Museum for a series (3 ♂ and 3 ♀) of *T brisbanensis*. The females are identical with females from New South Wales, and identified as *T. regis-georgii* at the British Museum

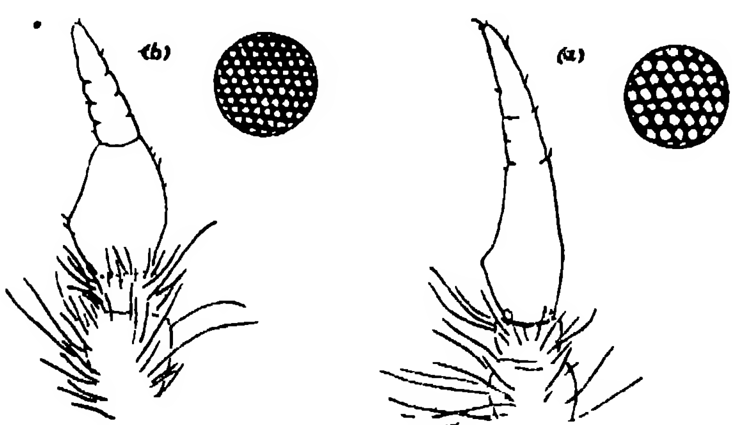


FIG 1

Text figure 1a. *Tabanus regis-georgii*, Macq., ♂ antenna and eye facets.

The specimen from which this figure is drawn was sent from the Queensland Museum under the name of *T. brisbanensis*, Taylor.

b. *Tabanus diemanensis*, n. sp., ♂ antenna and eye facets.

Mr. Taylor has recorded *T. brisbanensis* also from Tasmania, at the same time pointing out certain differences between the females, though he does not regard these differences as of specific value. There is a long series of a species very close to *T. regis-georgii* among Mr. Hardy's Tasmanian Tabanidae, which probably are the same as the species Mr. Taylor had from Tasmania. Though the females are very close, the males present differences which appear to be certainly of specific value. Further details will be found under the following species:—

TABANUS DIEMANENSIS, n. sp (Text Figures 1b, 3)

Closely allied to *T. regis-georgii*, Macq., but differing in the more finely facetted eyes of the male.

♂ Long:—10 mm., width of head 4 mm., wing 9 mm.

Face and cheeks densely clothed with creamy yellow tomentum, and with long brownish hairs, beard yellow. Palpi nearly as long as proboscis, second joint elliptical, yellow, set with long hairs, creamy at base, brown nearer apex. Proboscis very short. Antennae reddish brown, the first joint more greyish, and the annuli blackish, first two joints with long hairs, yellowish on undersurface of joints, brown above; third joint noticeably shorter (though somewhat variable in length) than in *T. regis-georgii*, with basal portion broader and more distinctly angulate, annuli shorter. Eyes contiguous, densely clothed with long black hairs, with larger facettes occupying the upper and inner two-thirds, becoming finer below, and also towards the upper margin, these larger facettes noticeably smaller than the corresponding ones in *T. regis-georgii*.

Thorax with a broad median band from anterior margin to middle, indistinctly divided by a narrow paler median stripe, and continued from middle as a narrow, dark median stripe, also with narrower sublateral dark stripes and a short narrow stripe over each wing root, these dark stripes separated by narrower grey stripes; rather densely clothed with fine creamy decumbent pubescence, and with longer erect brownish hairs; rather small creamy tufts of hairs present above wing roots; shoulders with dark hair tufts; sides with tufts of long creamy yellow hairs brownish in centre. Scutellum dark brown, the apical margin grey, and fringed with long creamy hairs.

Abdomen dark brown, the segmentations broadly banded with lighter colour, varying from light brown to creamy, and forming

a series of median triangular spots on each segment, second segment with sides and basal border pale; pubescence black on dark portions, bright creamy almost golden on pale areas and segmentations. Venter light yellowish brown with bright semi-erect creamy pubescence.

Legs with femora blackish, tibiae yellowish brown, and tarsi infuscate.

Wings hyaline, the costal cell, extreme base and cross veins very lightly suffused with brown, stigma brown, conspicuous; small appendix present.

Long:—10 5 mm., width of head 4 mm., wing 9 mm.

♀ Resembles male, forehead moderately broad, wider anteriorly than at vertex, densely covered with yellowish grey tomentum, brownish in centre; callus pear shaped, varying in shape and width. Palpi with second joint rather long, curved, rather slightly thickened at base

Hab:—Tasmania, Bream Creek (G. H. Hardy, 18/2/18); Wedge Bay (G H. Hardy, 28/2/18); S. Bruni Is. (Dr. Clarke, Jan., 1916).

The series before me shows great variation in the colouring of the abdomen; in many the dark markings on the abdomen are reduced to little more than a basal spot.

From the ♂ of *T. brisbanensis* (= *T. regis-georgii*) the present species differs in the more finely facetted eyes and in the

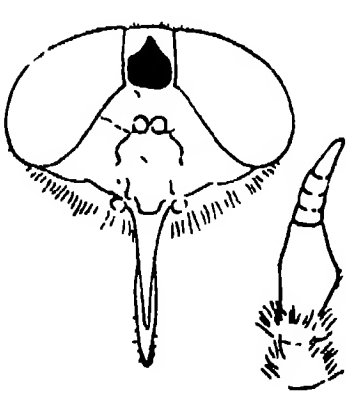


Fig. 2.

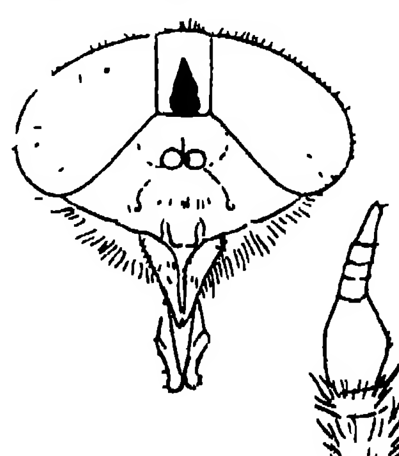


Fig. 3.

Text figure 2. *Tabanus regis-georgii*, Macq., ♀ head and antenna. Specimen from Kendall, New South Wales.

Text figure 3. *Tabanus diemanensis*, n. sp., ♀ head and antenna.

differently shaped antennae, though in this last respect the series shows some variation. Females are harder to distinguish, as a rule, however, the callus is longer and narrower than in *T. regis-georgii.* Great variation is shown in this respect; in some the callus is as broad as in many specimens of *T. regis-georgii;* in most, however, it is narrower and more elongate, while in some it is almost linear, and very different from the very broad rounded callus of many specimens of *T. regis-georgii.* In general the Tasmanian species is darker, and more hairy than the mainland one, of which it is the island representative.

Types in Australian Museum (presented by G. H. Hardy).

TABANUS IMPERFECTUS, Walk.

Walker, List. Dipt. 1, p. 179 (1848); Ricardo, Ann. Macq. Nat. Hist. (8), XVI., p. 278 (1915); White, Roy. Soc. Tasmania (Papers and Proc), 1915, p. 11.

Mr. Hardy's collection contains six specimens of this species from Hobart. Miss Ricardo states that Walker's type was from New South Wales; Walker himself, as noted by White, merely gave the habitat as New Holland, but as White has compared the Tasmanian specimens with the type, their identity is certain. I have never met with the species among the numerous specimens of *Therioplectes* I have had under examination from the mainland. The hairs are long and white on the eyes, much as in *T. antecedens,* and the large frontal callus combined with the small size will enable the species to be readily identified. In some specimens there is evidence of slight shading of the transverse veins of the wing.

TABANUS HOBARTIENSIS, White.

Roy. Soc. Tasmania, Papers and Proc., 1915, p 13.

Specimens collected by Mr. Hardy at Hobart in December and January may belong to this species. They, however, all differ in some details from White's description; thus the forehead is slightly narrower at the vertex than anteriorly, the thoracic pubescence is golden rather than white, and the knees, though blackish, could hardly be described as "broadly black." The anal cell also is not closed right in wing margin, but is united to it by a short stem which, however, varies in length.

As the specimens are, however, from the type locality of *T. hobartiensis,* I prefer to leave them under that name until a specimen can be compared with the type.

Tabanus tasmaniensis, White.

White, loc. cit., p. 8.

To this species I refer five specimens taken by Mr. Hardy on Cradle Mountain, in January, 1917. They agree very well with Mr. White's description, except that the abdomen is not "unusually broad and flattened."

The eyes are densely covered with long, whitish pubescence, much as in *T. antecedens*, frontal callus broad reaching eyes on either side, without any extension. Wings with basal portions of veins and cross veins suffused brown, the same colour also occurring along the costal cell and at extreme base of wing.

A male agrees with the females; eyes contiguous, with white pubescence, facets uniform in size; frontal triangle dark grey with grey tomentum; vertex with long black hairs.

EXPLANATION OF PLATES.

Plate I

Pelecorrhynchus flavipennis, n. sp.

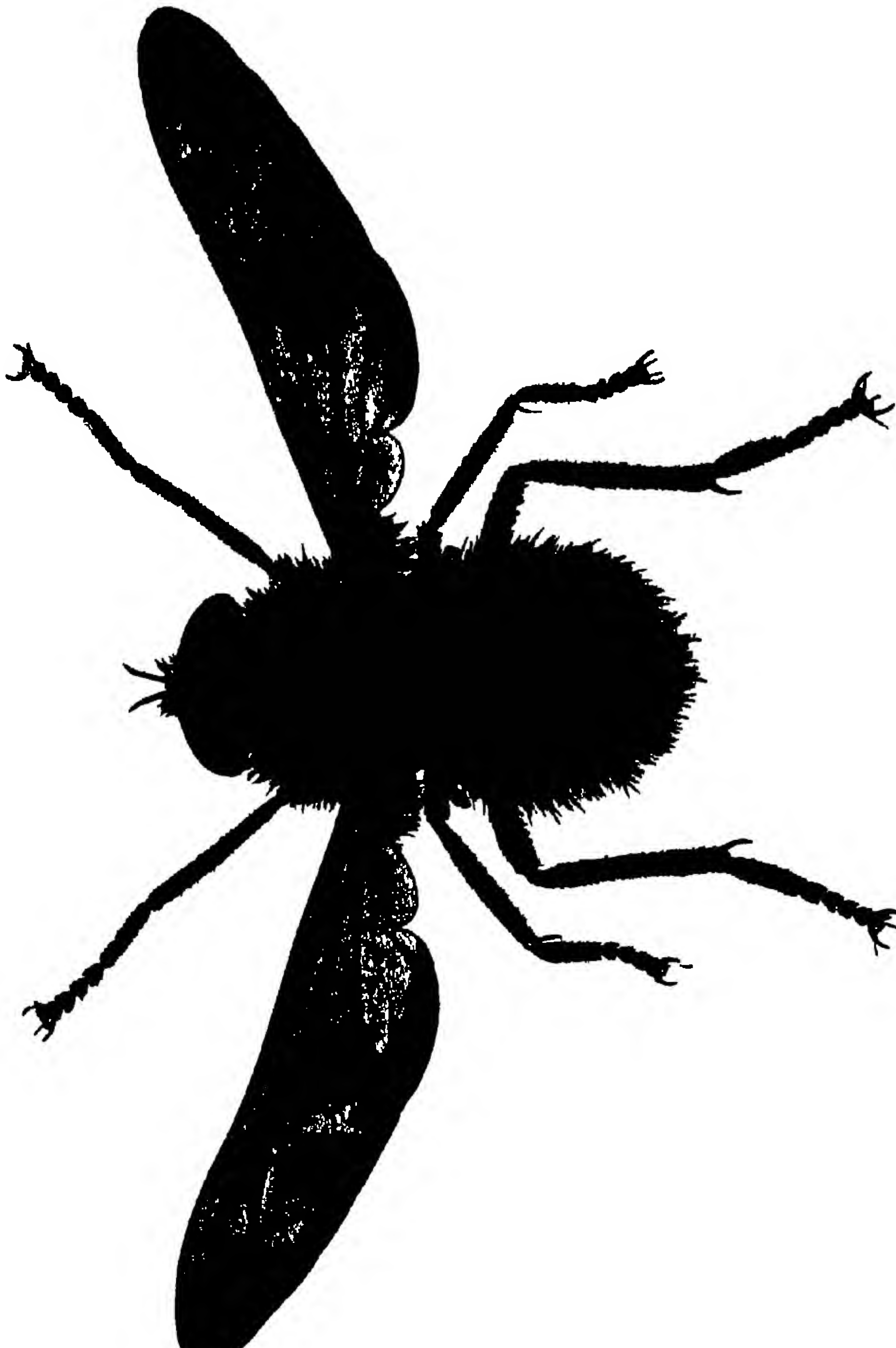
Plate II

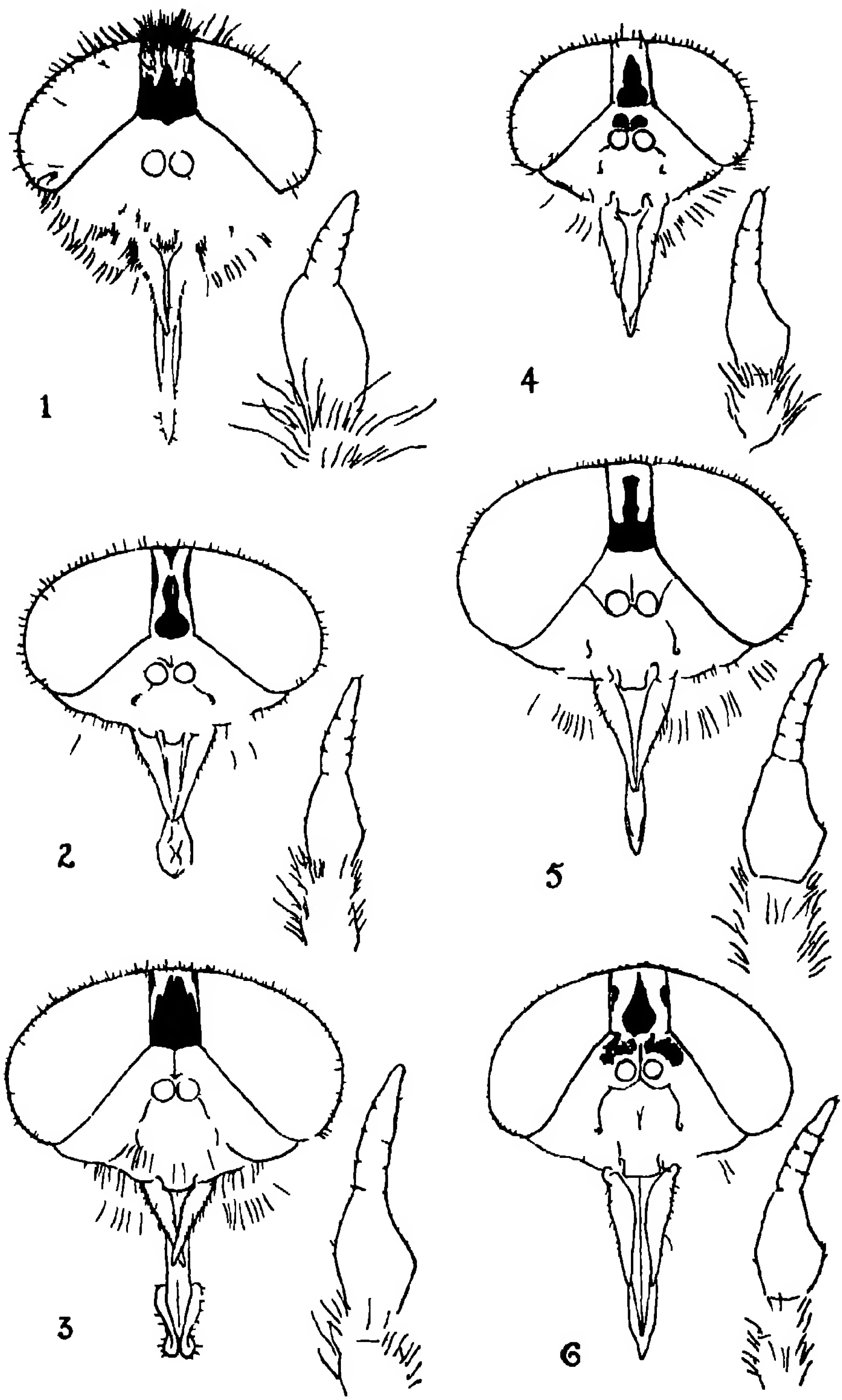
Fig.	1.	*Tabanus*	*latifrons*, n. sp,	head	and	antenna.
„	2.	„	*tasmanicus*, n. sp.,	„	„	„
„	3.	„	*antecedens*, Walk.,	„	„	„
„	4.	„	*bassii*, n. sp.,	„	„	„
„	5.	„	*edentulus*, Macq.,	„	„	„
„	6.	„	*dixoni*, n. sp.,	„	„	„

Postcript (added December, 1920).—Owing to the delay in publication, additional information has become available in the case of certain of the species treated in the above paper.

Pelecorrhynchus flavipennis, n. sp.—The allied species alluded to in the notes on this species has now been described as *Pelecorrhynchus deuqueti*, Hardy (Records Australian Museum, XIII., No. 1, p. 38). This may be distinguished by the different coloured thorax, and the yellow legs.

Erephopsis subcontigua, n. sp.—Additional localities, Marlee, near Wingham (C. F. Pfeiffer, Nov.-Dec., 1920); Dorrigo (T. Wright, Nov., 1920).

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Parasilvius, n.g.—This genus is certainly distinct from *Palimmecomyia*, of which I have examined the genotype.

Tabanus regis-georgii, Macq.—The synonymy of this species has already been published (Proc. Linn. Soc, N.S.W., XLV, 3, 1920., p. 466).

Tabanus hobartiensis, White.—A specimen has now been compared with the type, and the identification confirmed.

[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921].

Art. II.—*Description of a New Species of Corethra (Mochlonyx) from Australia.*

By E. W. FERGUSON, M.B., Ch.M.

[Read 11th March, 1920.]

The sub-family *Chaoborinae (Corethrinae)* is poorly represented in Australia, the only species previously recorded being *Chaoborus (Corethra) queenslandensis,* Theob. The discovery of a species belonging to the genus *Corethra* is therefore of special interest, particularly as the genus has hitherto been recorded only from the Northern Hemisphere. I have followed Brunetti (Records Indian Museum, IV., 1911, p. 317) in sinking *Mochlonyx,* Loew, 1844, in favour of *Corethra,* Meigen, 1803.

Corethra australiensis, sp. n.

Small, dark brown, legs yellowish, unbanded.

♂ Head dark brown, clothed with greyish tomentum, brownish near base, with long somewhat scattered brown hairs; palpi brown with brownish hairs, longer on basal joints; antennae plumose, brown, the basal part of each joint behind the whorl and the extreme apex white, the two apical joints entirely brown: hairs long, brown, set in whorls on each joint, except the last two, on which the hairs are shorter, and which are also clothed with fine whitish pubescence. Thorax dark brown, with a narrow median darker line, densely clothed with yellowish brown tomentum, more greyish posteriorly, and with scattered brown hairs. Abdomen dark brown, somewhat lighter at bases of segments, with scattered brown hairs, a few yellowish ones intermingled; apical segment with lobes short, stout, rather strongly curved; venter with scattered yellow hairs. Wings hyaline, veins light brown rather thinly set with dark brown setose hairs, first fork cell one and a-half times the length of second, its base nearer to base of wing, the first cell two and a-half times as long as stem; posterior cross vein short, about twice its length distant from mid-cross vein. Legs yellowish, with brown hairs, tarsi broken.

♀ Agrees with male, with the usual sexual differences: Antennae with shorter whorls and lighter brown; palpi darker than antennae; head with rather conspicuous golden yellow hairs.

Thorax as in ♂, but with finer yellow hairs in addition to stouter brown ones. Abdomen brown, the posterior borders and sides of segments with long golden yellow hairs and shorter yellow ones elsewhere; venter with similar scattered hairs. Wings as in ♂ but posterior cross vein longer; the veins rather more hairy. Legs with first tarsal joint considerably shorter than second joint.

Dimensions:—♂ long, 4.5 mm.; ♀ long, 4 mm.

Hab.:—Victoria.

The specimens described above were bred out by Mr. F. P. Spry from larvae obtained at Nyora, Victoria, by Mr. J. Searle, and presented to the National Museum, Melbourne, where the types will be found.

I am indebted to Mr Edwards of the British Museum for specimens of *C. culiciformis*, de Geer, the European species, for comparison. From this *C. australiensis* differs widely in its smaller size, its darker colour, and its clothing, the European species being clothed with long conspicuous golden hairs, and having the wings much more hairy.

C. cinctipes, the American species differs *inter alia multa* in the banded legs.

A specimen in the British Museum collection labelled *C. lapponicus*, Bergroth, is a much larger and otherwise different species.

[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921].

Art. III.—*Floral Abnormalities in the Genera Eriostemon and Glossodia.*

By ISABEL C. COOKSON, B.Sc.

(With Plate III and 4 Text Figure.)

[Read 13th May, 1920.]

1. Eriostemon.

Specimens of flowers of *Eriostemon obovalis, Cunn.*, were found in the early spring of 1919, which even on superficial examination had deviated from the normal form. These at first were found on one bush only, but on that bush every opened flower was abnormal. When the same abnormality was also observed on three other plants, all in close proximity to the one first found, I decided to collect material, an examination of which has led to the following result:—

Occurrence and Nature of Abnormality.

The plants occur in the Castlemaine district, in the hills which lie between the townships of Chewton and Fryerstown. *E. obovalis* grows well, and very abundantly in this area. Four abnormal plants in all were found. Two of these, about twelve feet apart, are large bushes, evidently a few years old, whilst the remaining two are smaller, and probably younger. Each of the latter is one foot from one another, and about two feet from one of the larger plants.

The fact that quickly drew my attention to these bushes was the unusual appearance of their flowers. These were slightly smaller than the normal, with petals more or less erect, in contrast to the expanded petals of the normal flower. The reason for this was not hard to find, for even without the aid of a lens, a small outgrowth containing pollen was seen to be present on the ventral surface of almost every petal. In most cases the five petals were all antheroid, but in others, one, two, or more were found to be without this structure. After the examination of a great number of buds and opened flowers, three only were found to have all their petals completely devoid of anther structure.

The normal flower of *E. obovalis* has five somewhat strap-shaped petals, which are always fully expanded, exposing the two whorls of stamens to view. (Plate III., Fig. 3.)

The typical abnormal flower also has five petals, similar in colour to the normal; these, however, never become fully expanded, but remain more or less erect, partially blotting the stamens from view. Each petal has a distinctly waved outline, and the tip of the lamina is generally incurved, forming a little hood, as it were, around the anther, which is situated a little above the middle line, on its ventral surface. No other change is noticeable, the sepals, stamens, and carpels being the number characteristic of the genus. (Plate III., Fig. 2.)

An extreme type of abnormal flower, and one of far less frequent occurrence is figured on Plate III., Fig. 4. In this case the lamina of each petal is modified to form a narrow filament-like structure, with a small expanded distal portion on which the anther is placed. It has been found, as is shown in Text figure 1, that the degree of reduction of the petal is dependent upon the simplicity or complexity of the anther it bears. The complex anthers here present will therefore account for the extreme modification of the petals, to such an extent that the latter are hardly distinguishable from true stamens. This resemblance is further emphasised by the presence of short hairs on the filamentous portion of lamina, similar to those present on the staminal filaments.

Structure of the Anther.

For the examination of the structure of the petal and anther, microtome sections were used, all of which were stained with Delafield's Haematoxylon. Petals from unopened buds have been used both for this purpose, and for the examination of the form of the anther and its relation to petal. This was done principally to facilitate obtaining complete drawings with the camera lucida, under a low power of the microscope, but also because of the greater abundance of buds than opened flowers in the material.

The anther is very variable in form and structure—as all gradations are met with, from the simple unilocular to the complex quadrilocular condition. These stages are shown in Text figure 1, and may be summarised as follows:—

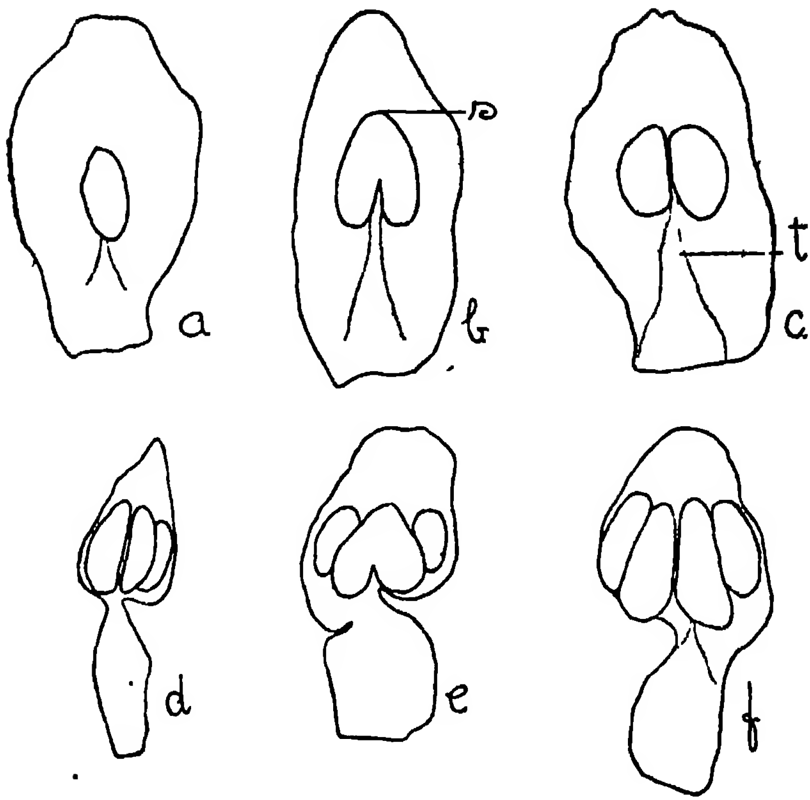


FIG. 1.—STAGES IN THE COMPLEXITY ANTHER FORMATION

a. Shows the simplest stage of anther formation in which a single loculus is present
b. Translation stage from unilocular to bilocular condition.
c. Bilocular anther.
d. Trilocular anther.
e. Transition stage from trilocular to quadrilocular condition.
s Point at which dehiscence takes place.
t. Cells rich in tannin.

In Plate III., Fig. 5, is figured a vertical section of a young antheriferous petal, the anther of which contains four loculi. Here the lamina is feebly developed, so that the whole structure, petal and anther, strongly resembles the appearance of a similar section of a normal anther. Pollen grains and a tapetal layer are present in each pollen sac.

In Text figure 2, the section represented is one of a more mature petal. The tapetal cells have disappeared, whilst the mechanical elements of the anther are strongly developed. The

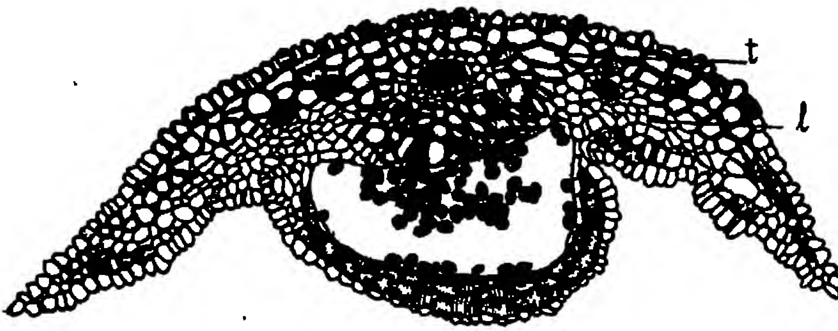


Fig. 2.

Transverse Section of Petal Bearing Unilocular Anther.

1. Lamina.

t. Thick walled tannin-containing cells.

anther is unilocular, and its fibrous layer is clearly seen. The cells in the region between the vascular bundle of the lamina and the anther have their walls considerably thickened. In fact, just before dehiscence the great majority of the cells of the petal have the annular and reticulate thickenings so characteristic of the mechanical tissues of anthers. Above and on either side of the vascular strands are large thick-walled cells, which contain tannin, and the cells of the upper epidermis also have thick walls.

In the drawings of both sections the cell contents, such as Tannin and Hesperidin, so freely present, have been omitted.

Dehiscence in the simple forms of anther takes place by means of a split, which develops at the distal end of the anther in such a way that a space is formed between the wall of the anther and the under epidermis of the petal. In this way the pollen, which is abundantly developed, and apparently quite normal, may be seen escaping. In the more complex forms of anther a longitudinal dehiscence takes place.

Discussion.

The only reference to any teratological abnormality in the genus *Eriostemon*, given by Penzig, in his " Pflanzen Teratologie," is one to a record by Dr. Masters[1], of the occurrence of double flowers in *E. obovalis*. He writes as follows: " Both specimens are remarkable as illustrating the occurrence of double flowers in Australia. . . . The supposed infrequency in such plants is due probably to imperfect observation rather than to absolute deficiency." This variation in the number of parts is indeed quite

1 Gard. Chron., 1877, pt. 2, p. 726.

commonly met with, there being either an increase or decrease in the number. The parts of the corolla are the members most usually affected, but one specimen noted had the floral formula—$K_5C_5A_{5+5}G_5$.

Several examples of "Staminody of the Corolla" are given by Masters[2] and Worsdell[3]. As far as can be ascertained, however, the occurrence of partial staminody of the corolla in the genus *Eriostemon,* has not been previously noted; this short account has therefore been deemed justifiable.

The fact that more than one individual illustrated this occurrence, and that two are obviously younger, and so probably the offspring of one of the larger ones, led me to think that this phenomenon might recur from year to year. Such has proved to be the case, for an examination of this year's buds has, in every instance, shown the presence of the abnormality above described. It therefore seems quite possible that these characters are those of a variety of *E. obovalis*, which has developed from the type as a mutant, but this fact can only be definitely determined by further observation and experiment.

2. Glossodia.

In the spring of 1919 two anomalous specimens of *Glossodia major,* R. Br., were found, both of which were characterised by the possession of two labella, as well as an abnormal arrangement of the perianth segments. Mr. E E. Pescott tell me that the occurrence of two or more labella in the genus *Glossodia,* and the allied genus *Caladenia*, is of no very uncommon occurrence, a few specimens being obtained each year; but, as far as can be ascertained, very little attention seems to have been given to these forms.

Specimen A.—(Text fig. 3) the perianth segments are six in number, the three outer calyx lobes being very similar to the two lateral corolla lobes, in size, shape and colour. The median anterior petal is in the form of a labellum, or "lip," which is bulged and dilated, with the distal region purplish, tapering to a point. The labellum bears a blunt, yellow appendage.

Specimen B (Text fig. 3) was collected by Miss S. Altman at Beaconsfield. It varies from the normal, firstly in the development of a median flat petal (p 3), quite indistinguishable from the two paired petals, and secondly in the development of two quite perfect labella, one on either side of the antero-posterior

2 Vegetable Teratology, 1869, p 298.
3 Principles of Plant Teratology, 1916, vol II, pp. 153-156.

plane. Each labellum is quite similar in shape and colour marking to that of the normal flower Apparently the anterior corolla lobe, instead of being developed in the form of a "lip," has become flat and petal-like, the two labella present being developed alternately with this structure, and hence the position of the two lateral stamens of the outer whorl There is no evidence save their position to suggest that they are due, to the modification of these two missing stamens

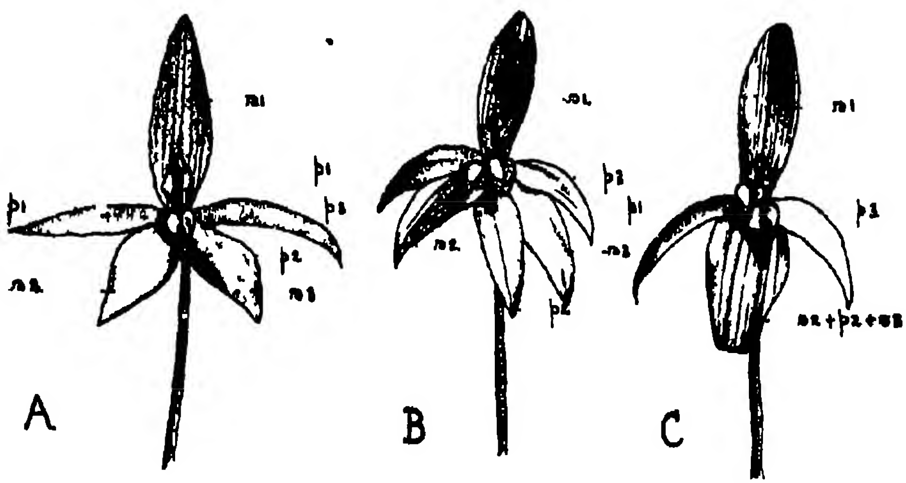


Fig 3

A Normal B and C abnormal flowers of *Glossodia major*
s sepaloid p petaloid segments of perianth

Specimen C (Text fig 3) was found by the writer at Chewton, and fundamentally the abnormality is similar to the one above described In the anterior region of the flower a flat petaloid expansion is situated the apex of which is divided into three notches At its proximal end and in the median line it bears

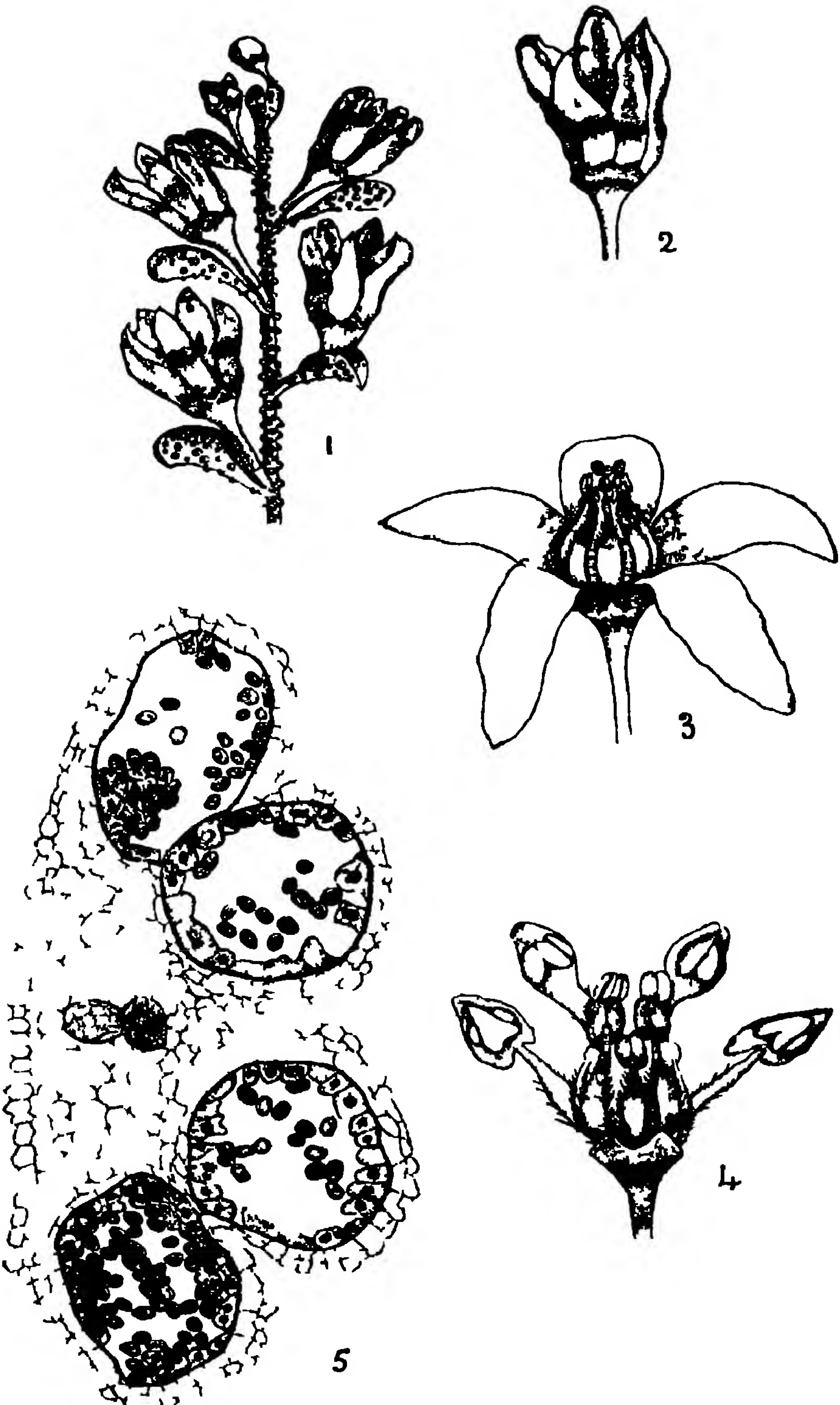
Fig 4—Anterior Compound Lobe of Specimen C Enlarged
s sepaloid, p petaloid components
a appendage

a small cylindrical outgrowth, which is fused with the petal-like structure for about half its length, the remaining portion being free. Two perfect labella are present, alternating with the median portion of the compound perianth segment.

The interpretation is that the median lip is here replaced by a flat petal, which has become fused with the two lateral sepals to form a single anterior compound lobe $S_2+S_3+P_2$. The evidence for this conversion of the lip to a flat petal, is firstly the presence of three notches at the apex of the compound segment, the median one of which suggests the anterior petal, and secondly the presence of a rudimentary appendage, attached to the middle region. If this view is taken, the two labella which alternate with the median segment are in the position of the two lateral stamens of the outer whorl.

EXPLANATION OF PLATE III.

Fig. 1.—Shoot of *E. obovatus.* showing abnormal flowers.
" 2—An abnormal flower, slightly enlarged.
" 3.—A normal flower, enlarged x 5.
" 4.—An extreme type of abnormal flower, in which the petals are almost reduced to the condition of stamens. x 5.
" 5—Transverse section of petal bearing a quadrilocular anther. Pollen grains and tapetal cells are shown.


1
2
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[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921].

Art. IV.—*The Relationships of the Sedimentary Rocks of the Gisborne District, Victoria.*

By W. J. HARRIS, B.A., and W. CRAWFORD.

[Read 8th July, 1920.]

I—Area Dealt With.

The area dealt with in this paper is roughly rectangular, and includes about 170 square miles. It is bounded on the east by the Sunbury to Lancefield railway, on the north by Mount Macedon, on the west by Goodman's Creek, and on the south by a

line from Sunbury to Coimadai. It includes the areas represented by Quarter Sheets 6 SE., and 7 NW. of the Geological Survey of Victoria, and by portions of QSs. 6 SW. and 7 NE. The surveys for these sheets were carried out by C. D. Aplin and N. Taylor, under the direction of Dr. A. R. C. Selwyn. Graptolites collected by the Survey parties were described and figured by Sir F. McCoy.[1] In an area so extensive, and in parts practically unsurveyed, there is room for division of opinion on geological questions, and our opportunities have not permitted as thorough an examination of all portions of the district as we could wish. For sufficient reasons, we have excluded from this paper all detailed consideration of igneous rocks. The boundaries shown on the accompanying Sketch Map have been copied in the main from the Quarter Sheets, or from the map of Messrs. Skeats and Summers.[2] We ourselves have made few alterations in the actual boundaries, though we differ from the earlier maps in our classification of the rocks shown.

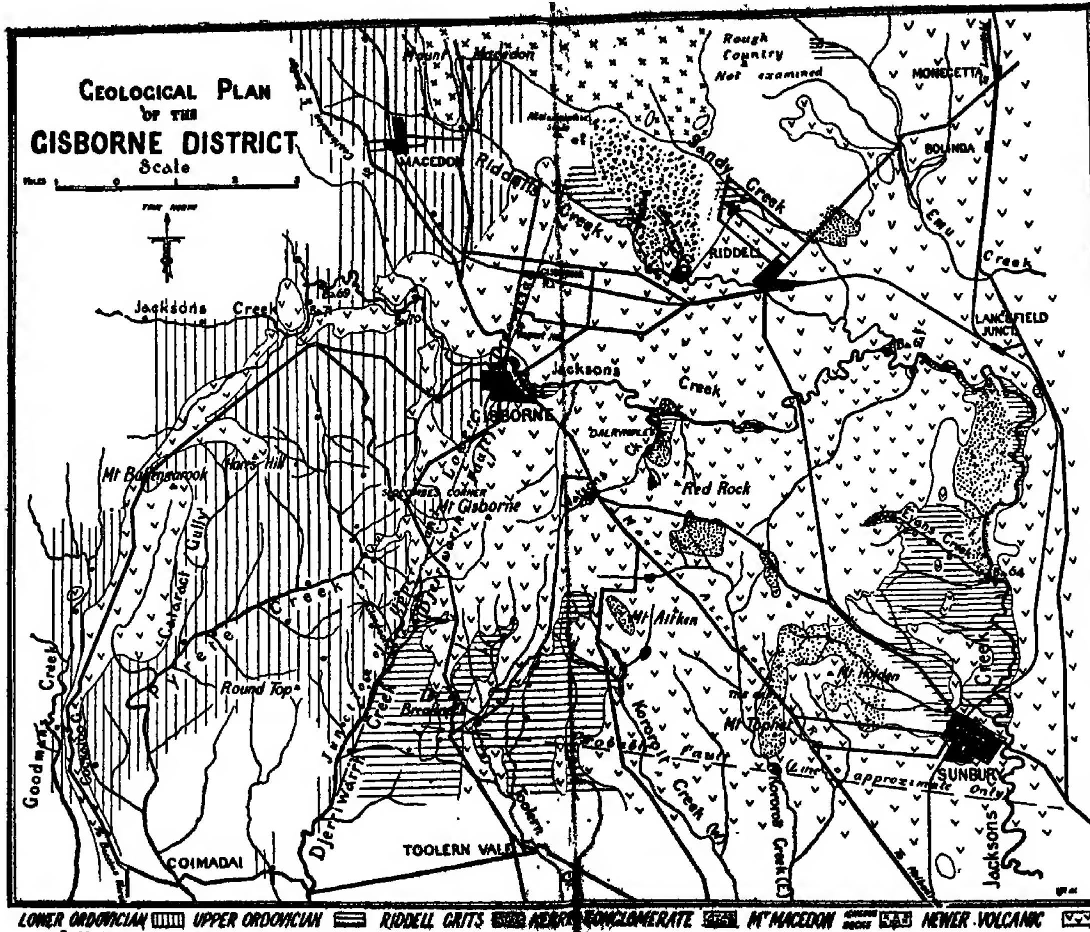
II.—Previous Literature.

During the last half century the area seems to have received scant attention geologically, except in so far as the northern portion has been included in an account of Mount Macedon by Messrs. Skeats and Summers.[2] While our investigations were in progress the Defence Department published two contour maps covering the southern portion of the area. Dr. C. Fenner's paper on the Werribee River,[3] though mainly concerned with the area to the south and west, is also of interest. Dr. T. S. Hall[4] identified graptolites from the Coimadai side of the district.

III.—Nomenclature.

As in many other parts of Victoria, the local names of streams and topographical features in general do not always agree with those shown on the maps, nor are the maps always in agreement with each other. On the Quarter Sheets the main stream of the district is shown as the Saltwater or Macedon River; McCoy[5] refers to it as the Saltwater; the military sketch map of the Macedon and Lancefield District marks it the Macedon River;

1. 1.
2. 4.
3. 5.
4. 6.
5. 1, Dec. 1, pp. 9, 14.



GEOLOGICAL PLAN OF THE GISBORNE DISTRICT
Scale
Rough Country Not examined
MONEGETTA
BOLINDA
Emu Creek
Sandy Creek
RIDDELL
MACEDON
Riddells Creek
Mount Macedon
LANCEFIELD JUNCT.
Jacksons Creek
GISBORNE
Red Rock
Mt Gisborne
Mt Bullengarook
Hars Hill
Cataract Gully
Round Top
Mt Aitken
Mt Holden
Mt Tophet
SUNBURY
Jacksons Creek
Kororoit Creek (E)
Kororoit Creek (W)
Djerriwarrh Creek
TOOLERN VALE
Toolern
COIMADAI
Goodmans Creek
Lime approximate Only
LOWER ORDOVICIAN
UPPER ORDOVICIAN
RIDDELL GRITS
NEWER VOLCANIC
FOSSILS

above Gisborne it is often called the Gisborne Creek, and below Sunbury, the Jackson's Creek, which is the name adopted by the Military Survey for its contoured plan, and will be the name used throughout this paper.

The Pyrete Creek is unnamed on the Quarter Sheets, on the Geological Survey Map of Victoria, and on the county plan of Bourke. On this last plan its lower course is shown as the Coimadai Creek, which is the local name for that portion of it. On the Military Survey map the name is spelled Pyrett. On the county plan a small eastern tributary of the Djerriwarrh is called the Parrait.

On the Quarter Sheets, east of the Gisborne-Melton Road we have, in order from west to east, the Toolam Toolern, Yangardook and Korokoit Creeks. On the county plan the first becomes the Toolerrn Toolerrne! On the military map it is abbreviated to Toolern Creek, its local name, while the Yangardook becomes Condon's Creek.

Broadbent's "Holiday Map," which, though unofficial, is of great help in the field, is very inaccurate as regards names in the Pyrete district. The upper Pyrete is not marked; the course of Goodman's Creek and neighbouring streams, apparently copied from the defective county plan, are incorrect. Goodman's Creek should flow south; the stream shown as the Cockatoo is known locally as Cataract Gully, Cockatoo Gully being a smaller gully nearer Coimadai; while the name Durdiwarrh, borrowed from the Steiglitz district, is misapplied to the Djerriwarrh, and the Toolern Creek is called the Toolam Toolam.

On QS. 6 S.E the fossil locality at the mouth of Riddell's Creek is shown as Ba 68, instead of Ba 67 McCoy[6] in referring to the same locality calls it "Ba 67, Section 24, Parish of Bulla." The outcrop in Section 24, Bulla, is Ba 68.[7]

IV.—Classification of Rocks in the Area.

(a) Geological Survey Classification.

From the account of previous work it will be seen that the Geological Survey Quarter Sheets are geologically the chief guide for the greater part of the district, though we have availed ourselves of the Memoir of Messrs. Skeat and Summers in our work on the Macedon section, while Dr. Fenner's paper has also been of use.

6. 1, Dec. 1, pp. 10, 11, 12.
7. Communicated by Mr. F. Chapman, A.L.S., National Museum.

Within the mapped area the Quarter Sheets show the following rocks, Macedon igneous rocks excluded.

(i.) Alluvium.
(ii) Upper Volcanic.
(iii.) Newer and Older Pliocene.
(iv.) Oolitic.
(v.) Lower Silurian.

Of these the Lower Silurian would now be termed Ordovician. The so-called Oolitic is the Kerrie Conglomerate.

(b) Proposed Revised Classification.

We propose the following classification:—

(i.) Alluvium.
(ii.) Newer Volcanic.
(iii.) Pre-Newer Volcanic Gravels.
(iv.) Kerrie Conglomerate.
(v.) Riddell Grits.
(vi.) Upper Ordovician. Shales, slates and sandstones.
(vii.) Lower Ordovician. ,, ,, ,, ,,

This classification differs from the earlier one in its division of the Ordovician, in distinguishing the Riddell Grits as a distinct geological phase, and in specifically indicating the Kerrie Conglomerate.

V.—Physiographical Features.

Physiographically the district may be divided into two areas, western and eastern. The division line is the Djerriwarrh fault line running south from Gisborne to the Djerriwarrh Creek, the valley of which follows it for some distance. This fault determines the boundary of Upper and Lower Ordovician. Lower Ordovician rocks predominate in the western area, but are not found in the eastern, which is for the most part covered with basalt of the Newer Volcanic flows. Throughout this eastern area are more or less isolated exposures of palaeozoic sedimentary rocks, of which the oldest are Upper Ordovician. Upper Ordovician rocks do not appear west of the fault line. (Fig. 3).

The stream development of the western area has been profoundly modified by the Djerriwarrh Fault, and the lava flows from Mount Bullengarook and Hare's Hill. As showing the pre-Newer Volcanic age of the Djerriwarrh Fault, it may be noted that it in no place dislocates the basalt, and, secondly, that in parts all trace of it has been obliterated by the infilling

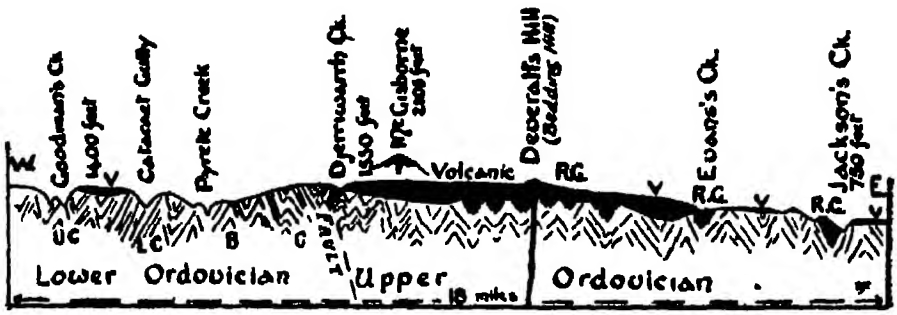
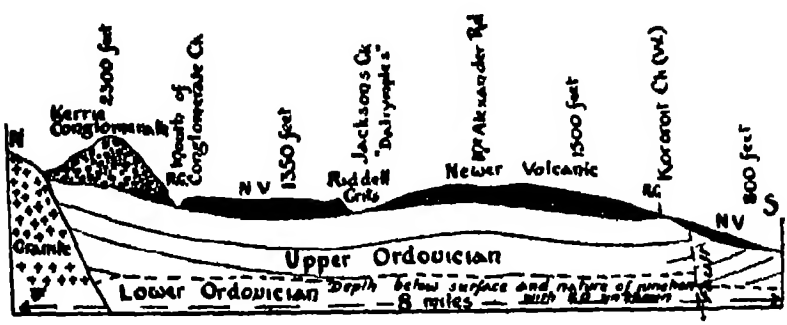


Fig 1 Section across central part of district, bearing E 15°N (mag.) Diagrammatic



.Fig 2 Section — Sandy Creek to Toolern Vale, bearing N 3°E (Diag.)

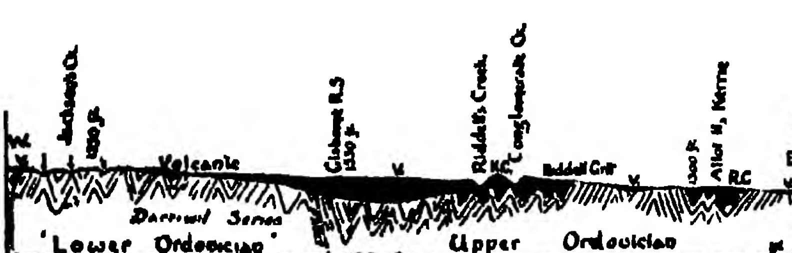


Fig 3 Section across northern part of district, bearing E 10°N (mag.) — Diagrammatic.

by basalt of valleys cut back from its scarp. Such infilled valleys occur north-west of Gisborne, near Slocombe's Corner, and at the Glendoon Spur. (QSs. 6 SW. and 7 NW.)

There is evidence that the Macedon platform was a definite geological feature at the time of the faulting, the throw seeming to diminish as it approaches Mount Macedon, while north of the Mount no dislocation is shown by the palaeozoic rocks, Lower Ordovician (Darriwil) graptolites being found at Woodend, east of Carlsruhe, and at Newham.

While the evidence for the re-construction of obliterated physiography must of necessity be more or less inconclusive, it is probable that the history of the western area is as under:—

(a) Previous to the Djerriwarrh Fault a stream—the "ancient Bullengarook" of Messrs. Officer and Hogg—rose north of Gisborne, and flowed south-west towards Bacchus Marsh.

(b) The Djerriwarrh Fault reversed the direction of the portion of this stream west of Gisborne, so that a new local watershed was formed near the present Mount Bullengarook.

(c) On this Divide volcanic activity built up Mount Bullengarook and Hare's Hill, which sent lava flows down the valleys to the north-east and south-west, forming the ridge now followed by the Gisborne-Bacchus Marsh Road, and also the outliers along upper Jackson's Creek.

(d) Erosion in post-Newer Volcanic times developed the present stream system

Further details will be given when treating of the eastern area. It may be noted that the northern and north-eastern slopes of the Bullengarook area are gradual, and are covered by wide-spread gravel deposits. The southern slopes, the Pyrete Ranges, consist of steep hills often 1600 feet above sea level, sloping steeply to valleys 200 or 300 feet below. Gravels are absent. The highest bed rock in the area is around Mount Bullengarook. Sediments outcropping on the Bacchus Marsh road on the north-western slope of the mountain are 1900 feet above sea level.

The development of the drainage system of the eastern area is typically what may be expected on an extensive lava flow which has covered and obliterated the earlier river valleys. The higher portions of the watersheds project as hills, or have been exposed by vertical erosion. The position of these inliers indicates that

the pre-Newer Volcanic streams trended southerly, and were divided by north and south water partings.

Following the main stream—Jackson's Creek—northwards from Sunbury, we find that it has cut down on to Upper Ordovician shales and Riddell Grits. From Lancefield Junction westwards there are alternating outcrops of Newer Basalt and palaeozoic rocks—Upper Ordovician and Riddell Grits, the basalt representing the old valleys and the sediments the intervening watersheds. There is evidence that the older valleys were in a mature state, and pre-Newer Volcanic gravels rest on their slopes in many places. Some of the earlier streams would naturally be larger than others, and in particular two large streams indicated by the wider stretch of basalt seem to have converged from N.E. and N.W. to a confluence near Mount Aitken, and then to have trended south between Mount Tophet and the Western Kororoit Creek. (See Fig. 2.)

Proceeding west to the Djerriwarrh Fault, the most important change, the reversal of the Upper Bullengarook to form portion of Jackson's Creek, has already been referred to. The waters of this reversed stream, and of its original source north of Gisborne R.S., would flow to the south through the Mount Aitken Gap. The Upper Pyrete, with its boat hook tributaries, probably flowed north at this period, and added its waters to the same stream. The main laterals of the Bullengarook lava field were Goodman's Creek and Cataract Gully. Goodman's Creek had scope for development, flowing over homogeneous rocks, but Cataract Gully found its activity limited by the resistent basalts of Mount Bullengarook and Hare's Hill. An eastern tributary better situated for erosion developed into the main stream—now the south-west reach of the Pyrete. This diverted the head waters of the Glendoon Creek from the Djerriwarrh system, taking from it the reversed drainage which the Glendoon had captured from Jackson's Creek. The history of the Upper Pyrete and its tributaries would thus be:—

(a) They were formed by drainage flowing north to Jackson's Creek consequent on the reversal of the direction of the latter by erosion westward form the Djerriwarrh Fault.

(b) They were captured by the Glendoon Creek, most likely after the volcanic outbursts, the southern grade being much steeper than the northern, partly owing to rejuvenation consequent on an east and west fault through Coimadai.

(c) They were in turn captured from the Glendoon by an eastern tributary of Cataract Gully, to form with this tributary the present Pyrete Creek, the erosive power of the Glendoon having been considerably lessened by the Mount Gisborne lava field.

The following classification of streams may be interesting. In preparing it the authors have had the benefit of Mr. R. A. Keble's co-operation, and have also used his paper on Lava Residuals.[8]

Pre-Newer Basalt Cycle	(a) Pre-Djerriwarrh Fault	Bullengarook (infilled) Eastern and western sub basaltic streams and tributaries (infilled).
	(b) Post-Djerriwarrk Fault	Upper Jackson's Creek (reversed portion of Bullengarook (infilled) Djerriwarrh Glendoon Slocombe's (infilled) Upper Pyrete (originally flowing north) Several infilled streams
Newer Basalt Cycle		Many streams obliterated by successive lava flows.
Post-Newer Basalt Cycle		Goodman's Creek. Cataract Gully. South-west reach of Pyrete Jackson's Creek. Riddell's Creek. All streams on Newer Basalt.

VI.—Lower Ordovician.

(a) Distribution and Fossils.

Lower Ordovician rocks were found only to the west of the Djerriwarrh fault. They comprise sandstones, slates and shales and differ little in appearance from rocks of similar age in other parts of Victoria. The prevailing strike seems to be slightly east of north, as compared with a strike of slightly west of north in the Bendigo, Castlemaine and Daylesford districts. The easterly strike, however, prevails in the more southerly Steiglitz area. The predominance of sandstones, the covering of surface soil, the almost entire absence of artificial sections, and a troublesome cleavage, render the delimitation of graptolite zones

8. 7.

difficult. Bendigo, Castlemaine and Darriwil series are all typically represented. The lowest beds seem to be those west of the Djerriwarrh Creek in the south-west of the mapped area. Beds, probably Middle Bendigonian, and lower than any previously recorded from the district, are indicated by—

Tetragraptus fruticosus (4-branched), J. Hall.
Tetragraptus pendens, Elles.
Phyllograptus cf. typus, J. Hall.
Goniograptus thureaui, McCoy.
Goniograptus macer, T. S. Hall.
Didymograptus similis, J Hall, and others.

Of Bendigonian age also are the rocks of the south-west bend of the Pyrete, though the presence of *Didymograptus bifidus* at at some outcrops indicates the upper beds of the series just below the typical Wattle Gully (Lower Castlemaine) beds of Dr. Hall.[9] The beds are in fact transitional between the Bendigo and Castlemaine series.

Lower Castlemaine beds occur both east and west of these. They were traced for some distance south on the western side of the Djerriwarrh Creek, then they outcrop in the bed of the stream, and finally cross it. These beds are of interest on account of their nearness to Upper Ordovician shales—a point to be enlarged on later—and because in them we found a gasteropod determined by Mr. Chapman to belong to the genus *Helicotoma*, practically the sole representative at present known of the Victorian Lower Ordovician mollusca. The beds yielded—

Didymograptus bifidus, J. Hall.
Didymograptus caduceus, Salter.
Phyllograptus cf. typus, J. Hall.
Tetragraptus pendens, Elles
Tetragraptus serra, Brong.
Tetragraptus quadribrachiatus, J. Hall.
Clonograptus abnormis, J. Hall.
Goniograptus crinitus, T. S. Hall.
Rhinopterocaris maccoyi, Eth. fil.
Helicotoma sp.

The presence of *D. caduceus* with *D. bifidus* is unusual, but the two species are found together occasionally in the Castlemaine district and elsewhere. On the western side of the Bendigo beds we found in Cataract Gully—

9. 8, pp. 69-70.

Didymograptus bifidus, J. Hall.
Didymograptus caduceus, Salter.
Phyllograptus cf. typus, J. Hall.
Tetragraptus serra, Brong.
Dichograptus octobrachiatus (juv.), J. Hall.
Goniograptus crinitus, T. S. Hall.

From Basin Creek, south of this last locality, Dr. Hall[10] has recorded graptolites belonging to the same zone.

Middle Castlemaine beds with Phyllograptus and D. caduceus occur along the Upper Pyrete.

Upper Castlemaine and Darriwil graptolites are found in many parts of the district, west of Glendoon Creek, on the Glendoon Spur, and at the new but now abandoned slate quarry south-west of Slocombe's Corner, but particularly along Goodman's Creek (Upper Castlemaine), in Cockatoo Gully, and between the Bacchus Marsh Road and Woodend Along Jackson's Creek, above Gisborne, slate bands are common. At localities like the old slate quarry on the creek north-west of Gisborne, a good collection of Upper Castlemaine forms may be obtained, while further down the creek near Ba 69 and Ba 71, and north of Ba 70, Lower Darriwil forms occur, the following being recorded:—

Didymograptus caduceus, Salter.
" " var. *manubriatus*, T S. Hall var.
" " var. *forcipiformis*, Rued. var.
Didymograptus uniformis, Elles and Wood.
Didymograptus v-deflexus, Harris Ms.
Oncograptus upsilon, T. S Hall.
Trigonograptus, sp.
Diplograptus, sp.
Goniograptus speciosus, T S. Hall
Tetragraptus serra, Brong.

From Ba 71 "on the east bank of the Saltwater River one mile north from the Bacchus Marsh Road," Sir F. McCoy's[11] records—

Tetragraptus fruticosus, J Hall,
Phyllograptus typus, J. Hall,
Dichograptus octobrachiatus, J. Hall,

a perfectly consistent group indicative of the Bendigo series. Repeated search failed to reveal graptolites at the exact spot,

10. 9, p. 202
11. 1, Dec. 1, pp. 9, 14, 18.

and Mr. F. Chapman kindly examined the Melbourne National Museum collection without finding any fossils from Ba 71. Surface wash may have obscured the outcrop, but field evidence leads us to doubt the occurrence of Bendigo beds at this particular locality. All outcrops we have examined north of the Bacchus Marsh Road have yielded Upper Castlemaine or Darriwil species and these occur plentifully 200 or 300 yards north of Ba 71 along the line of strike. They also occur half a mile to the south.

Outcrops, interesting on account of their field relations, their accessibility, and the representative nature of their facies occur along the railway line south and north of Macedon R.S. The southerly locality, Lower Darriwil, yields almost the same species as Ba 69 and 70, i.e., the typical *Oncograptus* fauna. *Lasiograptus* is also found. A continuation of these beds outcrops in the Turritable Creek a short distance upstream from the crossing of the Upper Macedon Road. The northerly locality—in a cutting north of the 45 mile post—is Middle Darriwil, and, in addition to previously recorded forms, *Cardiograptus morsus*, Harris and Keble, is also common. Localities along the railway further north yielded few graptolites, and those found were in all cases referable to the Darriwil series. Similar graptolites are recorded from Allot. 1, Sect. Va, Newham, by Drs. Skeats and Summers.[12]

North and west of Macedon, and near the Campaspe west of Woodend, there are several outcrops, all of which appear to be of Upper Castlemaine or Darriwil age. At Ba 74, west of Woodend, one of the commonest forms is a narrow *Diplograptus,* found also at Guildford, in the Werribee Gorge, and recorded by one of us[13] as *Diplograptus*, *cf. angustifolius*. Along Goodman's Creek we obtained Upper Castlemaine graptolites from numerous outcrops, some of which may be on the same band of slate. From Cockatoo Gully we have recorded similar fossils, and, in one case, *Oncograptus upsilon*, showing that the beds here approach the Darriwil series. As in the case of the *D. bifidus* beds, our results here are in agreement with Dr. Hall's record.[14]

(b) *Structure of Area.*

It has been demonstrated that all the Lower Ordovician series except the Lancefieldian are represented in the Gisborne district.

12. 4, p. 41.
13. 18, p. 70.
14. 6, p. 208.

The distribution of the beds shows that the country between Slocombe's Corner and Goodman's Creek forms the arch of a geanticline. This is represented diagrammatically in Fig. 1. The prevailing dip in the east is westerly, apparently owing to inversion, as the Upper Ordovician rocks appear to dip below the Lower Ordovician. The sequence of graptolites denotes a prevailing northerly pitch. This may be partly due to faulting, in which case it would be necessary to assume a down-throw to the north or opposite to that of the larger faults further south. It is both possible and probable that faults, of which we have no knowledge, are responsible for the meagre development of Middle Castlemaine and Victoria Gully beds.

VII.—Upper Ordovician.

(a) Distribution and Fossils.

On the Quartersheets Upper and Lower Ordovician are both included in the Lower Silurian, but Upper graptolites are recorded by Sir F. McCoy from Ba 64[15] (on Jackson's Creek near the mouth of Evans Creek), and from Ba 67[16] (at the junction of Riddell's and Jackson's Creeks). With the recognition of Darriwil graptolites at Macedon the east boundary of the Lower Ordovician was brought within six miles of known Upper Ordovician beds. One of our tasks was to reduce this distance still further. Our plan was to work down Jackson's Creek from Gisborne, but fortune favoured us at the outset, as we discovered Upper Ordovician graptolites in a "wash-out," or gulch, which runs from the Mount Alexander Road to Jackson's Creek, at the south-east of Gisborne township. This discovery pushed the Upper Ordovician boundary about 30 miles west of the longitude of Melbourne.

The Upper Ordovician rocks consist of hard quartzose bands, coarse and fine sandstones and shales. The shales range from black and carbonaceous to a pipeclay-white, and, except in the west of the area, are usually decomposed. All the Upper Ordovician rocks have been subjected to great pressure, to which they seem to have yielded more readily than the Lower Ordovician. The hardest bands are often contorted, and are sometimes pinched out altogether. Slickensided faces are common. The slates in the bed of the Djerriwarrh are traversed by thousands

15. 1, Dec. 1, pp. 10-12.
16. 1, Dec. 11, pp. 33, 34.

of minute faults, rarely with a throw of much more than an inch.

Such is the nature of the Upper Ordovician rocks that it is usually difficult to collect graptolites sufficiently well preserved to enable specific identifications to be made with any confidence. Moreover, so varied are the appearances which a form such as *Diplograptus* can assume with different angles of compression, that even with favourable material diverse views may be taken. Lastly, except for generic purposes, the mere outline of the rhabdosome is of little value when dealing with Upper Ordovician graptolites.

Collections at all extensive have been made from only a few outcrops. Most localities, however, are enormously rich in individuals. Lists of identified graptolites from a few typical localities will give some idea of the fauna. Ba 64, on Jackson's Creek, north of Sunbury, yielded—

> *Diplograptus*, spp. including forms with a dilated virgula.
> *Climacograptus bicornis*, J. Hall.
> „ „ var. *peltifer*, Lapworth var.
> *Dicranograptus ramosus*, J. Hall.
> „ *ziczac*, Lapworth, or *D. furcatus*, J. Hall.
> *Dicellograptus cf. sextans*, J. Hall.
> „ *cf elegans*, Carruthers.
> *Glossograptus*, sp.
> *Leptograptus* (?).

The identification of the last genus is doubtful. Dr. Hall[17] has recorded a *Leptograptus* from Lancefield, but recognised[18] that it was not a typical member of the genus, and neither his figure nor description of *L. antiquus* seems to present the characteristics of the genus as described by English[19] and American[20] authorities. *Leptograptus* is elsewhere an Upper Ordovician genus and has been recorded by Dr. Hall from the Upper Ordovician shales of the Matlock district.

Ba 67, at the junction of Riddell's and Jackson's Creek, is wonderfully rich in beautifully preserved forms, so that one cannot but regret the absence of the *Dicranograptidae*. We record—

> *Diplograptus*—several species, one of which is very common, and is recorded by McCoy[21] (probably erroneously) as *D. pristis*, Hisinger sp.

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17. 9, p. 166, Plate XVII., Figs. 5 and 6.
18. 10, p. 440.
19. 11, p. 104.
20. 13, p. 260.
21. 1, Dec. 1, p. 11, Pl. I., Fig. 6.

Climacograptus, sp.
Glossograptus, recorded by McCoy as *Diplograptus mucronatus*.[22]
Nemagraptus (?).
Cryptograptus tricornis, Carruthers.
Pleurograptus, or an allied genus.
Retiograptoid form.
Didymograptus, sp.—horizontal forms.
Rhinopterocaris maccoyi, Eth. fil.
Siphonotreta micula, McCoy.

A third locality is the Gisborne "wash-out," already mentioned. The shales here are white and light blue, slickensided, and decomposed. In some bands graptolites are plentiful, but, as might be expected, badly preserved; yet, strange to say, forms showing distinct retiograptid structure were found. There occur—

Dicellograptus sextans, J. Hall.
,, *cf. elegans*, Carruthers.
Diplograptus, spp.
Climacograptus, sp.
Glossograptus, sp.
Didymograptus, sp.
Nemagraptus gracilis, J. Hall.
Retiograptus geinitzianus, J Hall.

Many of the other outcrops are indicated on the map.

No attempt has yet been made to indicate graptolite zones in the Upper Ordovician rocks of Australia, nor has sufficient information been gathered to warrant any detailed attempt. The difficulties encountered in identification have already been mentioned. These difficulties, the poor state of the fossils, and the absence of the economic considerations which directed attention to the Lower graptolite shales of the goldfields, are responsible for the comparative neglect of richly fossiliferous beds within 30 miles of Melbourne. The geological survey of Northern Gippsland[23] has already provided valuable material, and further work in that area may solve problems for which nearer localities furnish insufficient data. We have found that the following distinctions seem to hold good throughout the district we have studied:—

22. Ibid. p. 10, p. 10, Pl I., Fig. 5
23. 13, p. 7 (Detailed references in footnote).

(I.) Beds without Dicellograptus and Dicranograptus, but containing Didymograptus, Diplograptus and Climacograptus. The Ba 67 outcrop is typical. Similar beds occur on the Upper Djerriwarrh and elsewhere.

(II.) Beds with the same species as (I.), but with Didymograptus rare, and containing Dicellograptus also. These outcrop at Gisborne, along the Djerriwarrh and Glendoon Creeks, and on the Toolern Creek.

(III.) Beds differing from (II.) by the addition of Dicranograptus, as at Ba 62, Ba 64, Dalrymple's and other outcrops along Jackson's Creek, and also along Evans Creek.

The scattered nature of these outcrops renders correlation difficult, but we are inclined, on phylogenetic grounds, to arrange the beds as under:—

Uppermost—

(I.) Dicranograptus beds.

(II.) Dicellograptus beds.

(III.) Diplograptus-Didymograptus beds.

Upper Ordovician records from other parts of the State,[24] and from New South Wales,[25] seem to show the same three zones, but throw no light on their stratigraphical relations. The absence of Dicranograptidae from Ba 67, the common occurrence of Glossograptus, Didymograptus and Cryptograptus, all forms found also in the Lower Ordovician, and the diplograptid characters of the commonest species of Climacograptus, are some of our reasons for placing this outcrop below the others. On the Toolern Creek a Dicellograptus is found, which is either *D. Smithi*, Rued., or closely allied to it. *Dicellograptus smithi* is cited by Ruedemann[26] as indicating the tendency of a Dicellograptus to develop Dicranograptus characters. If this be so, Dicellograptus beds would be expected below those containing Dicranograptus. In America and Great Britain Diplograptus and Climacograptus survive, as well as precede, the Dicranograptidae. They may therefore occur in beds above the highest given in the above table. From such beds Didymograptus would be absent.

24. 13, p. 7 (Detailed references in footnote).
25. 14.
26. 13, p. 109, et seq.

(b) *Relation to Lower Ordovician—Critical Sections.*

As far as the writers are aware, there is no record of the observation of the junction of Upper and Lower Ordovician in Victoria. Between Ba 67 and Ba 70, the nearest outcrops of Upper and Lower graptolite shales shown on the Quartersheets, the distance is 7½ miles. Our discovery of Upper Ordovician fossils at Gisborne narrowed the gap to less than two miles. By making traverses further south we still further reduced this distance, and finally succeeded in ascertaining the junction within a few yards. The actual junction cannot be indicated, since, unless one were to judge by lithological characters, there is no evidence by which Upper and Lower Ordovician unfossiliferous rocks may be distinguished. Taken as a whole, Lower Ordovician sandstones are unlike those of Upper Ordovician age, but the test is not one which can be safely applied to any limited outcrop. The shales are more distinctive, but cannot invariably be recognised by texture and colour.

An account will now be given of some sections across the boundary line, commencing near the north of the area, and working south.

(I.) From the extreme north of the district, Messrs. Skeats and Summers[27] record graptolites obtained near "Cheniston," Upper Macedon. Dr. Hall referred these to the Darriwil series. In the same beds we discovered *Loganograptus logani*, confirming the reference to Lower Ordovician. To the east of the Barringo Creek badly preserved graptolites were found in metamorphosed shales Whether they were Upper or [27A] Lower Ordovician could not be determined. North of Riddell's Creek, further east, *Diplograptus* and *Climacograptus* were obtained.

(II) North of Gisborne township, a short distance, upstream from Cherry's saw mills, Lower Ordovician graptolites occur. Arenaceous shales in the bed of an old channel of Jackson's Creek yielded—

Didymograptus caduceus, Salter.
Didymograptus, spp.
Tetragraptus quadribrachiatus, J. Hall.
Diplograptus, sp.
Glossograptus, sp.
Loganograptus, cf. logani.

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27 4, p. 41.

27A The discovery of *Climacograptus bicornis*, var *peltifer*, Lapw var, has since shown these beds to be Upper Ordovician.

Trigonograptus ensiformis, J. Hall.
Cryptograptus tricornis, Carruthers.
Phyllograptus, sp.
cf. Thamnograptus.
cf. Cardiograptus.

This assemblage of graptolites presents several interesting features. The association of *Diplograptus* with *Phyllograptus* is found elsewhere, as for example at Ba 29, Sect. 20, Newham, from which locality came some of the first Australian graptolites to be described.[28] The Newham or Cobaw outcrop is remarkable, an isolated patch of slate with well preserved graptolites in a soil covered and unfossiliferous area. Dr. Hall[29] recorded from it—

Didymograptus caduceus, Salter.
Diplograptus palmeus, Barrande.
Glossograptus mucronatus, J. Hall.
Tetragraptus quadribrachiatus, J. Hall.
Phyllograptus typus, J. Hall.
Goniograptus, sp
Lasiograptus, sp ,

and believing from his Castlemaine observations, that *Phyllograptus* disappeared below the Upper Castlemaine horizon,[30] concluded that both the Darriwil and Castlemaine series were represented. His belief that *Phyllograptus* was not found with *Loganograptus* was also probably responsible for the identification of Goniograptus instead of *Loganograptus*.[30] There is no doubt whatever that the collection is quite homogeneous. *Phyllograptus, Diplograptus* and *Lasiograptus* may be obtained on the same slab, and all the fossils are from one isolated band. One of us[31] has shown in an earlier paper that *Phyllograptus* reappears in the Middle Darriwil, and it now seems probable that it may persist at some localities into the Upper Darriwil series. The finding of *Cryptograptus tricornis* and the common occurrence of *Diplograptus* at the Gisborne outcrop, would place it very high in the Lower Ordovician, and it may be the highest bed yet recognised. *Cryptograptus tricornis* is elsewhere in Victoria an Upper Ordovician form, but it occurs in Lower Ordovician shales near Woodend, and at the " Cheniston " locality.

28. 1 and 16.
29. 16, p. 126.
30. 7, p. 73 and 10, pp. 441, 443.
31. 18, p. 67.

On the opposite side of the Mount Alexander Road, about 400 yards downstream to the east, a submerged band of rotten blue slate yielded *Diplograptus* only, but exhaustive search was impossible. The nearest Upper graptolite beds are about half a mile eastward, though unfossiliferous shales closer at hand are probably Upper Ordovician.

(III.) In Sect. 14, east of Gisborne Cemetery, decomposed blue shales gave *Diplograptus*. The age of the beds is unknown.

(IV.) In the bed of the Djerriwarrh Creek, between Allots. 4 and 5, Upper Ordovician graptolites occur. After crossing a basalt residual—the Glendoon Spur—Upper Castlemaine graptolites are found. The distance between the two outcrops is about 500 yards, and basalt covers the junction.

(V.) Upper Ordovician graptolites are found on the southern slope of the Glendoon Spur, and in the bed of the Glendoon Creek at its foot *Diplograptus*, *Climacograptus*, *Cryptograptus* and *Dicellograptus* occur, while the ridge on the western side of the creek gave—

Didymograptus caduceus, Salter.
" " var. *manubriatus*, T. S. Hall, var.
Didymograptus, horizontal species.
Trigonograptus, sp.
Goniograptus speciosus, T. S Hall

A traverse here must cross the junction of Upper and Lower Ordovician. We made several trips up and down the Glendoon Creek, but are unable to find any structural break. The blue Upper Ordovician slates are succeeded upstream by green and brown arenaceous rocks. The softer and probably fossiliferous bands are poorly exposed The first fossiliferous band above the *Dicellograptus* beds yielded only *Diplograptus* and *Cryptograptus tricornis*, Carruthers, and may be either Upper or Lower Ordovician, though we are inclined to regard it as Upper. In unpromising material further upstream we found the continuation of the hillside beds, and obtained the same forms as from the hill, with the exception of *Goniograptus speciosus*, and in addition—

Didymograptus v-deflexus, Harris Ms.
Oncograptus upsilon, T. S. Hall,

indicating plainly the Lower Darriwil horizon. There are variations of strike, but no clear line of division is indicated. As has been stated, the *Cryptograptus* shales between these Darriwil beds and the *Dicellograptus* slates down stream, may be Upper

or Lower Ordovician, but in either case, the vertical distance between the Upper and Lower fossiliferous rocks can only be about 100 feet.

The *Dicellograptus* shales outcrop downstream in the Glendoon Creek for some distance, and are continued south in the bed of the Djerriwarrh. A cliff on the right bank of the Djerriwarrh yielded—

Diplograptus.
Climacograptus.
Glossograptus.
Dicellograptus, cf. *sextans*, J. Hall.
Cryptograptus tricornis, Carruthers.
Nemagraptus gracilis, J. Hall.
Retiograptus, *cf. geinitzianus*, J. Hall

The next fossiliferous beds downstream yielded only a few specimens of *Didymograptus caduceus* after a long search, but the vertical distance between these Lower Ordovician beds and the Upper Ordovician cannot be greater than the interval between two zones of the Lower Ordovician at a typical locality in a district like Castlemaine. A little further south, Lower Castlemaine beds are found. The graptolites, etc., from these have already been listed on page 47. We measured the distance from these beds up a small tributary to *Dicellograptus* beds, and found it to be about 100 yards. The same beds were also traced north along the western bank of the creek, to a point not far west of Upper Ordovician outcrops in the creek itself. This was as far south as our detailed observations extended; but, further south, Middle Bendigo graptolites were obtained from the bed of a western tributary of the Djerriwarrh, and *Tetragraptus fruticosus* and *Didymograptus bifidus* were obtained from the Boggy Creek, west of Toolern Vale.

(c) Summary.

Nowhere was the actual junction between Upper and Lower Ordovician detected. The two series are undoubtedly unconformable, though the unconformity is not apparent in the field. It is difficult to imagine that Lower Castlemaine beds in one place, and Lower Darriwil, a little further north, are only a few hundred feet, or less, below *Dicellograptus* shales, unless they have been brought into that position by faulting, for there is nothing to indicate any great difference in the conditions of sedimentation at Gisborne, compared with those prevailing at

Bendigo, Steiglitz, or Castlemaine, and there cannot be the complete succession of beds between the *D. bifidus* beds and the Djerriwarrh *Dicellograptus* beds. The uniformity of the junction—a line running nearly north and south for several miles—suggests that we are most likely dealing with a fault. The Djerriwarrh valley appears to follow the fault line for some distance. All that can be said as to the age of the fault is, that it seems to be much older than the tertiary faults of the Werribee District. It is certainly pre-Newer Volcanic, and so old that, though it must have meant a considerable vertical displacement, the contour of the area is not dominated by it, though its effect on the physiography has been important. The throw is probably small in the north, and increases southwards. The down-throw or eastern block seems to have pivoted on the Macedon platform, and the break in the continuity of the shales north of Gisborne is probably small.

VIII.—Riddell Grits.

(a) General Survey.

Two miles south-east of Gisborne, a small stream known locally as Watson's Creek, crosses the Mount Alexander Road. On QS. 7 NW. there is the following note on this locality: "Hard gritty sandstone, grey and pinkish-white, containing minute fragments of fossils, is used for road metal." On some copies of QS. 7 NE the word "Fossils" appears in white letters on the coloured background south of Mount Holden, but it is absent from others, probably of another edition The absence of fossiliferous Ordovician sandstones of Ordovician age in Victoria, as far as we were aware, led us to examine the Watson's Creek outcrop carefully. The resemblance the rock bore to that which occurs at Allot. 11, Kerrie, referred to the Upper Silurian by Mr. Chapman,[32] was at once apparent, but the chief fossils were only casts of crinoid stems and obscure fragments of brachiopods. Our partial success led us to examine carefully

32 17, p. 225

NOTE.—While this Paper was in course of preparation, fossils were discovered in Lower Ordovician grits or coarse sandstones at Castlemaine by Mr. A. L. Hopkins, at that time a student at the Castlemaine High School. The commonest fossil has been identified by Mr. Chapman as an *Orthis* comparable with *Orthis flabellulum*, Sow. or *O. pectinella*, J. Hall Trilobite remains, probably referable to *Agnostus*, also occur, while impressions of phyllocarids are common. The writers have discovered indeterminate brachiopod remains near the Campaspe River, west of Woodend, and it is probable that Bs 75, QS. 10 NE. refers to a similar occurrence. All these outcrops are in the Castlemaine series.

every outcrop of sandstone and grit discovered. It was found that rocks outcropping at numerous places in the district could conveniently be grouped together, and for convenience we have called the series the Riddell Grits. The undoubted Upper Ordovician rocks have already been described—homogeneous sandstones and carbonaceous shales, usually finely laminated, and in extreme cases weathering to a soft clay. The most prominent beds of the Riddell Grits are of coarse sandstone and grit; in some places, as in Jackson's Creek, above "Dalrymples'," a gravel conglomerate. The bands are persistent, but within any band the texture changes, passing from grit to a fine sandstone or quartzite, evidently the effect of currents during deposition. The grit bands are slickensided, and their outer layers often show bulges and channels where they have been forced into less resistant rocks. In the coarser grits there are smooth-lined cavities resembling casts of fossils, but most likely caused by the removal by solution of small clayey patches. The grits are fossiliferous, but such is the nature of the rock, that well preserved fossils are unobtainable. Brachiopod casts, occasional gasteropods, corals, polyzoa, and most commonly the impressions of crinoid stems, are to be found. Mr. Chapman very kindly examined a large quantity of unsatisfactory material for us, and his identifications are given on pages 69-71.

With the grits, and in some localities, interstratified with characteristic grit bands, are mudstones or shales, brown, rubbly, and less finely laminated than the typical graptolite shales. There are also thin-bedded fine micaceous sandstones or arenaceous shales. It will be seen that the Riddell Grits represent a more shallow water deposit than the Upper Ordovician rocks already dealt with. Determination of their age is fraught with difficulty. The following points have to be considered:—

(i.) It is impossible to draw a sharp distinction between shales associated with the Grits, and normal Upper Ordovician shales, and the relation of the Riddell Grits to the Upper Ordovician may depend on the relation of the shales of the two series. As in the case of Lower and Upper Ordovician, typical shales of the two series differ greatly from each other, but no safe test can be applied to a limited outcrop. On account of this difficulty, and because of the nature of the country, it is difficult to ascertain the field relations of the Grits.

(ii.) *Diplograptus-Climacograptus* shales are interstratified with the Grits (though naturally graptolites are hard to find); and remains of *Diplograptus* occur in the Grit itself at some localities. At one outcrop—on the Western Kororoit Creek—sandstones apparently of the Grit series, yielded from thin, included, impersistent shales *Dicellograptus*, as well as *Diplograptus*. The sandstones in this case were not quite typical Riddell Grit, but we believe them to belong to that series.

(iii.) The fauna of the Grits, other than graptolites, in Mr. Chapman's opinion is Silurian, and even Yeringian (Upper Silurian). Mr. Chapman states: "The fossils indicate a mid or newer Silurian horizon. As a distinct horizon of grits, I should say they were basal, and, from the fossils, basal Yeringian. The *Leptaena* is of a type only found in the Newer Silurian, as also the *Encrinurus* and cf. *Eridotrypa*. The faunal elements suggesting an older phase of the Silurian, are the abundance of *Camarotoechia* and *Rhynchotrema*."

(iv.) Though there is no evidence of the fact, the Grits may not be all of the same series. Mr. Chapman states that as far as the fossils go, there is no evidence of more than one horizon, and there is a remarkable similarity in the appearance of the Grits at all outcrops. Still, at Springfield, east of Romsey, a lithologically similar band is interstratified with *Monograptus* shales.

Having stated some of the difficulties of the question we shall now proceed to discuss it.

(b) *Field Relations—Critical Localities.*

(1) Mouth of Watson's Creek—"Dalrymple's."

Following Watson's Creek to the north-east from the Mount Alexander Road, a walk of less than two miles brings one to its junction with Jackson's Creek, which here swings in from the west through a narrow gorge in the basalt, meanders through a small alluvial flat, and then continues eastward, hugging the foot of a high northern bank. This is an interesting locality, though, like many critical sections, its interpretation is difficult. (See Fig. 2.)

The first sedimentary rocks exposed upstream are Grits, striking. N.40°W., and dipping to the east. Then comes a series of muddy grey shales, soft and decomposed, and as far as we can ascertain, unfossiliferous. These are succeeded by a bluff of west-dipping sandstone with thin shale bands. The strike of these rocks is almost due north. Below the bluff, the section is not as clear as one could wish, but a coarse Grit band seems to run up into the hill to the north. Associated with it are rubbly brown shales or mudstones, such as are charactertistic of the Grit series elsewhere, and grey mudstones with pellets of gravel, seemingly derived from the coarse band. In the brown shales we find Diplograptus, and from the mudstone we obtained a single small gasteropod The bed of the creek is littered with large angular fragments of grit. All these beds dip to the west, and there is a syncline between them and the first Grit mentioned above. They strike more to the west than the sandstones of the bluff. The grit in the bands here is usually coarse. It might be regarded as a light conglomerate, and joints or shearing planes have cut pebbles and matrix in a manner suggestive of the Kerrie Conglomerate on a small scale. Among the debris of landslides from the steep bank of the creek are blocks of Upper Ordovician shale, which yielded a small collection of fairly well preserved graptolites. The band from which they are derived is to be found some height up the bank, but its relation to the shales below is obscured by soil and debris. We obtained—

Diplograptus, sp.
Climacograptus, sp.
Dicellograptus elegans, Carruthers.
Dicellograptus complanatus, Lapworth.
Dicranograptus furcatus, Hall, or *D. ziczac*, Lapw.

The rubbly shales cross the creek to the south, where the Grit bands stand out prominently in the bed of the stream.

On the downstream side of the alluvial flat we come to contorted rubbly shales striking at first N.10°W., separated by an unconformity from normal carbonaceous *Dicellograptus* shales dipping west, and striking N.40°W. A grit band crosses the stream further east, striking nearly north, but a soil covered flat separates it from the graptolite shales. To the north, a small tributary gully seems to expose only grits and *Diplograptus* shales, the *Dicellograptus* shales passing under the hill. The strike of the grits as one descends this gully from west to east,

varies from north-east to north, and the *Diplograptus* shales below them strike N. 20°W. The dip throughout this section is westerly, and the hill between the gully and the main creek shows nothing but grit, which seems to pass right over the *Dicellograptus* shales outcropping in the bed of Jackson's Creek.

This represents the most complete section, though it is incomplete at critical points. South of the main creek a steep "wash out" descends to Watson's Creek. The uppermost beds, below basalt, are arenaceous shales, apparently bent in a syncline. Below are grit, sandstones, and rubbly shales or mudstones, all apparently conformable, striking N 10°W., and dipping west. Below the lowest grit band *Diplograptus* and (?) *Dicranograptus furcatus* were obtained, but are very rare. In Watson's Creek, to the southward, are rubbly *Diplograptus* shales, striking N. 10°E., and dipping west, succeeded after an interval, by a grit band which strikes N. 10°W., and, if continued north, would pass through the "washout." Two or three hundred yards to the south-west, just past a north and south fence, *Dicellograptus* shales outcrop, striking N. 10°E., and dipping west, while still further upstream, decomposed shales, apparently of the Grit series, dip East, and strike N. 20°W. Grit boulders litter the hill slopes to the south-west. The *Dicellograptus* shales last mentioned are almost certainly identical with those on the bank of Jackson's Creek to the north, the graptolites of which are given in the list on pages 64, 65. Not only are the graptolites identical, but the colour, texture and lamination of both beds are identical and distinctive, not resembling those of any other locality with which we are acquainted. This is of importance in attempting a correlation of the rocks of the area.

We have dealt with this area in fair detail, because it represents perhaps the most intimate association of Grits and normal Upper Ordovician.

Our interpretation of the features we have described is only provisional. We sum up our observations as follows:—

1. Grits and rubbly *Diplograptus* shales are of the same series and are interstratified.

2. The "wash out" section indicates—

   (a) A syncline in the Grits.
   (b) *Dicranograptus* in associated shales.

We at first thought that there was evidence of an unconformity between the Grits and these shales, but further investigation leads

us to alter our opinion. The gap between Grits and *Dicranograptus* shales seems to be due solely to superficial debris.

3. This syncline is also indicated in Jackson's Creek, and by the occurrence of similar *Dicranograptus-Dicellograptus* shales on either side of the Grits.

4. Grits occur further east, but their relation to those already mentioned is not shown. They also cover the hill in the north of Jackson's Creek.

Our conclusions are:—

1. The Grit series here is in all probability Upper Ordovician.
2. It overlies *Dicranograptus* shales.
3. There is no evidence of normal Upper Ordovician graptolite shales overlying the Grits.

(ii.) Lancefield Junction

The Grits outcrop on the western slopes of Jackson's Creek, south of Lancefield Junction, and compose the hills as far south as Evans Creek, but were not found immediately south of that stream. These hills are exceptionally barren, comparing unfavourably even with Lower Ordovician and Kerrie Conglomerate This locality will be dealt with in two parts—(a) the section exposed in the creek, and (b) the hills south of the creek.

(a) Jackson's Creek, south of Lancefield Junction.—As Jackson's Creek comes from the west immediately before turning south at Lancefield Junction, Grit ridges appear on the right bank, and, if continued north, should cross the stream. Directly in the line of strike of these ridges, a low cliff forms the south bank of the creek, and, viewed from the far side of the stream, seems to be normal Upper Ordovician shales with a sandstone bar about the middle of the section, and it is so shown on QS. 6SE The bank is almost vertical, and there is a deep pool at its foot. A false step may mean an undesired bath. Working from the west along this section we cross *Diplograptus-Climacograptus* shales dipping east and broken by faults. The sandstone band is typical Grit. Some feet wide at the top of the bank it rapidly narrows, and is less than a foot wide at water level, and probably does not extend much further. It is followed by vertical or west-dipping shales, which gradually turn over to the east. These shales yielded *Diplograptus, Climacograptus* and *Glossograptus,* and the main Grits overlie them. On top of brown shales comes

an eight or nine inch band of grit, then two feet of shale, and finally massive grits.

The section is inconclusive on account of the absence of typical beds immediately to the east. The shales of this cliff are certainly Upper Ordovician. It is our opinion that all the rocks exposed belong to the Riddell Grits. If this be so, the Riddell Crits would appear to be Upper Ordovician also, nor would the position be altered if it should later be proved possible to separate the shales from the Grit series. As to what lies above the Grits we have here no evidence.

Further up the creek, *Dicranograptus* shales form a steep bluff, and after another break, we again find Grits interbedded with rubbly shales, with an occasional *Diplograptus*. Sandstones along this part of the creek also seem to belong to the Grits.

As this is perhaps the most accessible, and one of the most critical localities for the relations of Grits and Upper Ordovician shales the following references to QS. 6 SE. are given:—

The "arenaceous and micaceous light coloured shales and thin-bedded sandstones, 65-70°W, 25°S.," near the mouth of a small eastern tributary are *Dicranograptus* shales.

The bed rock across which this note is printed on the Quarter Sheet is Riddell Grit.

The "shales 80°W., 10°S." are Upper Ordovician, as are also the "cream-coloured and bluish-grey thin laminated shales and sandstones," further north.

The "bluish-grey and light coloured shales, middle bed sandstone, 75°E., 15°N.," are those just described in detail. The middle bed is Grit, and the eastern Grit band should be shown above the first letters of "sandstone."

The "bluish-grey shales 50°E., 5°N." are *Dicranograptus* shales.

The "coarse, quartzose grit, E. 30°N. and E. 40°N.," are the Grits referred to as interbedded with rubbly *Diplograptus* shales.

Grits occur also near the western limit of the bed rock area shown. The section is not continuous, as would be inferred from the Quarter Sheet, for between the various outcrops the bed rock is obscured by basalt or the wash from it.

The "white sandstone E. 65°S." is interstratified with carbonaceous shales, which yielded—

Diplograptus, sp.
Climacograptus bicornis, J. Hall.

Dicranograptus nicholsoni, Hopkinson.
Dicranograptus furcatus, Hall, or *zic-zac*, Lapw.

The "purple grey shales" at the mouth of Riddell's Creek are at the locality Ba 67, and are Upper Ordovician.

(b) Lancefield Junction, south and west of Jackson's Creek.—We have already mentioned the Grit hills which lie between Lancefield Junction and Evans Creek. Two ridges, composed of Grit, run almost north and south, converging towards the south. Each ridge represents a massive band, or series of bands, of grit, with fragments of which their summits and slopes are littered. The strike of the more westerly bands is about N. 20°W., and the dip east, so that the convergence of the two ridges is probably due to an actual convergence of two bands of grit, or of the same band on opposite limbs of a syncline pitching north from Evans Creek If this view be correct, the western limb would be represented by the faulted band in Jackson's Creek, while the eastern limb would be indicated by the low outcrop exposed east of this, the limbs being represented by the 75°E. 15°N., and the 75-85°W., 12-15°S., of QS. 6 SE. Such a pitching syncline would also explain our failure to find Grits between Sunbury and Evans Creek. In the small creeks which drain these Grit ridges bed rock is rarely exposed, with the exception of the more prominent grit bands, but in a few places the streams have worn down on to brown rubbly mudstones or shales. One such outcrop directly between the two ridges, and on our supposition above them, yielded *Diplograptus*.

Near the head of Evans Creek Grits outcrop also. The strike is N. 6°E. They are not seen in contact with the *Dicellograptus-Nemagraptus* shales downstream, which appear unconformable with them and below them. A north and south continuation of these last bands would take one to the "quartzose grits" on Jackson's Creek (QS. 6 SE.), and to the Grits of Mount Tophet and The Gap.

The area between the Jackson's Creek section described in (a), and Evans Creek, represents the largest continuous exposure of Riddell Grits in the district. A study of QSs. 6 SE. and 7 NE., or of the military map of Sunbury, will show the two ridges running south towards Evans Creek, separated by a north and south valley. Following the creek south from Lancefield Junction, all the rocks exposed in its bed as far as due west of the 28 mile post on the railway are *Dicranograptus* shales

striking slightly west of north, and dipping west. Then in the river, sandstones and brown rubbly mudstones are exposed, unfossiliferous, but seemingly of the Grit series. Further south, at the bend from south to east, north of Ba 64, a heavy fossiliferous Grit band crosses the creek, dipping west, and forming a small waterfall. Below it are conformable rubbly mudstones and shales, and then, after a space, we come to the *Dicranograptus* shales of Ba 64 striking almost due north, and dipping steeply to the east.

Ascending the valley of Evans Creek, the first rock exposed is an isolated exposure of grit, apparently the projecting top of an almost completely buried grit band. About 500 yards up from the river an easterly grit band crosses Evans Creek. Upstream from this there are numerous sandstone and shale bands, but no fossils were obtained from any of the sandstones, although there seemed to be no unconformity between them and the Grits to the east. A little over a mile upstream, the characteristic *Dicranograptus* shales appear. The shales in the interval are so interstratified with hard sandstones, that no detailed examination of them could be made. *Diplograptus* and *Glossograptus* were obtained from one band.

This area again gives no information about beds overlying the Grits. In the apparent syncline between the two Grit ridges the shales which there seem to overlie the Grit bands are most likely portion of the same series.

(iii.) Conglomerate Creek.

At the junction of Conglomerate Creek with Riddell's Creek Grits and *Diplograptus* shales are seen to underlie the Conglomerate. The Grits here lie above and to the east of the shales which yielded *Diplograptus*. In spite of the differences of strike and dip, it is possible that the shales here may belong to the Grit series. The shales dip east, and strike N. 10°W., while the Grits dip west, and strike N. 10°E. A band of Grit with the same strike runs up the slope towards the house on the spur, while further east are arenaceous shales. (See Fig. 3.)

(iv.) Bracken Gully.

In a small gully west of Conglomerate Creek Grits appear to pass under the Kerrie Conglomerate. The Grits outcrop in the floor of the gully. As the stream is followed northwards, a

small waterfall is reached. The lower four or five feet are Grit. Above lie impersistent layers of shale, and then the main mass of the Conglomerate. The Grit at the junction is penetrated by quartz veins, one of which in the base of the Conglomerate shows slickensides, the direction of movement being almost vertical. The shales on the hillside to the west yielded numerous specimens of poorly preserved *Diplograpti*, and similar fossils are found lower down the gully. The strike of the Grits and their relation to the shales at this locality could not be determined. Still further west, Grits appear at the creek level, while, higher on the slopes is the Conglomerate. A gully to the west shows thick bedded shales or mudstones forming, as it were, a pavement in the creek.

(v.) Sandy Creek Road.

On the Sandy Creek Road, near Allot. 76, a small cutting shows quartzose Grits, overlying *Dicellograptus* shales not quite conformably.

(vi.) Western Kororoit Creek.

South of the Grit outcrop at Watson's Creek on the Mount Alexander Road are other Grit outcrops—on the Eastern Kororoit Creek, north-west of Mount Aitken, north of the Western Kororoit Creek (Allots. XXVI.-XXVIII.) and along the same creek near where the parishes of Buttlejork, Yangardook and Holden meet.

Near the mouth of the small stream from Allot. XIX., Gisborne, are bluish *Dicranograptus* shales striking between E. and N.E., a most abnormal strike for this district, and dipping 65°N. North and south of these shales, not seen in contact with them, but apparently deflected by them, are sandstones with thin shale bands. The strike some 100 yards down stream is N. 20°W., but it changes further north to N. 18°E. The dip is steeply to the east. The sandstones contain brachiopods and the shales, *Diplograptus* and *Dicellograptus*, though graptolites are rare, and the shales are not such as would be expected to contain graptolites at all. Thick bedded sandstones outcrop further upstream, and along the Buttlejork tributary a vertical Grit band, striking N. 15°W., is succeeded by normal blue-black *Dicellograptus* shales which, at first vertical, turn and dip east at a high angle. Unless the beds are inverted we have here the only case where Grits appear to underlie *Dicellograptus* shales. This Grit band

is responsible for the south bank of the stream being littered with angular fragments, which yielded crinoid remains, brachiopod fragments, polyzoa, and, strange to say, *Diplograptus.*

(vii.) Other Localities.

On the Romsey Road (Sect. 11, Kerrie) the Grits and associated shales are alone visible. (See Fig. 3.)

At the head of Evans Creek, Grits outcrop, and have already been mentioned. Their relation to *Nemagraptus—Dicellograptus* shales lower down the creek is not clear. If massive sandstones just upstream from the shales belong to the Grit series the two are in all probability unconformable.

Other areas of Grit occur near Mount Holden, south and west of Red Rock, and at The Gap and Mount Tophet. South-west of Mount Tophet we get *Diplograptus-Climacograptus* shales, but their relation to the Grit is not evident. They may be its associated shales.

The close relation of the Grits to the normal Upper Ordovician will be at once seen from the following summary:—

I. "Dalrymple's" - -	
(a) "Wash-out"	Grits apparently bent in syncline overlying *Dicranograptus* shales. Dip and strike in agreement, and beds apparently conformable.
(b) Jackson's Creek	Grits apparently overlying *Dicranograptus* shales. Faulting Junction not seen.
(c) South of "Wash-out"	*Diplograptus* shales in creek, then Grit band and, after a considerable space, *Dicranograptus* shales. Relations not shown.
II. Lancefield Junction -	
(a) Jackson's Creek	Grits apparently overlying conformably *Diplograptus* shales and faulted with them.
(b) South of (a)	Grits apparently forming syncline, overlying *Dicranograptus* shales. Junction not observed. On west passing to normal Upper Ordovocian without any observed unconformity.
III. Conglomerate Ck and Bracken Gully - -	Grits and *Diplograptus* shales apparently folded together. Some difference in strike.

IV. Sandy Creek Road -	Grits overlying with some unconformity *Dicellograptus* shales.
V. Western Kororoit Ck. -	
(a) Eastern tributary	Vertical Grits apparently conformable with *Dicellograptus* shales and seeming to underlie them. The high angle of dip makes deductions unreliable.
(b) Main stream	Thick-bedded fossiliferous sandstones and *Dicellograptus* shales unconformable with *Dicranograptus* shales.

The Riddell Grits—coarse and fine sandstones, with associated *Diplograptus* shales, usually rubbly—seem everywhere to be closely associated with Upper Ordovician shales. On the field evidence, and on the evidence of their graptolites, they might well represent a shallow water phase of the Upper Ordovician.

There is no doubt that the Grits overlie *Dicranograptus* shales, apparently conformably. With the exception of the outcrop along the Western Kororoit Creek, there is no evidence of beds overlying the Grits conformably. Since along the Djerriwarrh Creek Upper Ordovician shales seem to pass below Lower Ordovician rocks, the result of faulting or overfolding, it is unsafe to generalise and state that the Grits are interstratified with the normal Upper Ordovician shales. The absence of overlying beds throughout most of the area lends considerable weight to the theory that they represent the last phase of the Upper Ordovician, and mark the beginning of the change to the shallower water conditions which prevailed during the Silurian period. At any rate, the presence of *Dicranograptus* below the Grits would seem to place them well up in the Upper Ordovician.

(c) *Fossils other than Graptolites.*

Fossils are abundant in the Grits, but are poorly preserved as casts. Mr. F. Chapman, A.L.S., of the National Museum, Melbourne, has identified the followings forms:—

(I.) "Dalrymple's," North-west of Red Rock, Gisborne.

(?) ***Plasmopora.***
cf. ***Stylaraea.***

(?) ***Fenestella.***
cf. ***Eridotrypa.***
Leptaena, sp.
Orthis, sp.

cf. *Rhynchotreta.*
Camarotoechia, sp.
Spirifer, sp.
cf. *Loxonema.*
cf. *Pleurotomaria.*
Heliolites sp. near *H. megastoma,* McCoy.
(?) *Heliolites* or allied form.
(?) *Rhynchonellid.*
(?) *Cannapora.*
(?) *Conchidium.*
(?) Monticuliporoid.

The species of *Heliolites* is distinct from the usual form found in the Yeringian in having the siphonopores feebly developed and the autopores crowded.

(II.) South of Red Rock, Gisborne—
cf. *Eridotrypa.*
Pseudocrinites sp. (food-groves, casts), seven specimens.

(III.) South-west of Lancefield Junction—
Coral (probably belonging to the *Chaetetidae).*
Rhynchonellids, indet.
Orthis (?) sp (of the *Platystrophia* type).

(IV.) North-west of Mt. Aitken, Gisborne—
Polyzoa, indet.
Leptaena sp.
Camarotoechia sp.

(V.) Watson's Creek, Mt Alexander Road, Gisborne—
cf. *Monotrypa.*
(?) *Rhynchotrema.*
Rhynchotreta sp.
Camarotoechia sp.

(VI.) Allot. 11, Kerrie, Romsey Road, Riddell—
Polyzoa, indet.
Leptaena sp.
Orthis sp.
Camarotoechia sp.
Rhynchotremea sp.
Atrypa sp.
Encrinurus sp.
cf. *Rhynchotreta.*
Cyrtolitid gasteropod (cast).

(VII.) Upper Western Kororoit Creek—

Polyzoa, branching form.

Crinoid, columnar, and impressions and moulds of crinoid arms.

Mr. Chapman adds: "The Fossils indicate a mid or newer Silurian horizon. As a distinct horizon of grits, I should say they were basal, and, from the fossils, basal Yeringian. The *Leptaena* is of a type only found in the Newer Silurian, as also the *Encrinurus*, and cf. *Eridotrypa*. The faunal elements suggesting an older phase of the Silurian are the abundance of *Camaratoechia* and *Rhynchotrema*." These identifications were made at an early period of our investigation, and represent the more obvious features of the fauna. Since they involved a distinct break between Grits and Upper Ordovician, and the field evidence pointed to a close connection, a more thorough search was instituted, resulting in the discovery of *Diplograptus* remains in the Grits themselves, and of *Diplograptus* and *Climacograptus* in shales interstratified with them. These fossils are rare, many hours of search resulting in the discovery of less than half-a-dozen specimens, but that they are typical is shown by their widespread distribution. They were found at "Dalrymple's," Lancefield Junction, Watson's Creek, and the Western Kororoit. This led us to transfer to the Grit series *Diplograptus* shales which we formerly considered distinctly Upper Ordovician, but which are of coarser texture, and more rubbly than the normal graptolite shales, and which are closely connected with grit bands. Since such shales had yielded *Dicranograptus* at "Dalrymple's," it was of importance to determine their relation to the Grits. This junction is obscured by soil, but after careful search, we are of opinion that shales and grits are here conformable.

We have also Messrs. Skeats and Summers' accounts of resorted Kerrie Conglomerate pebbles in Lower Silurian mudstones at Springfield. These mudstones are portion of a series which contains grits like the Riddell Grits in texture and fragmentary fossils, but which is Silurian, *Monograptus* occurring in shales above and below it.

We assume, as will be shown later, that the Riddell Grit is older than the Kerrie Conglomerate, and, if we adopt Messrs. Skeats and Summers' theory of the origin of the Springfield pebbles, then the Riddell Grit would be not later than the Lower Silurian.

(d) Summary.

For the sake of clearness we shall recapitulate our results:—

(1) The Riddell Grits are a series of sandstones, grits, mudstones, and shales, the shales being typically more rubbly than the common Ordovician graptolite shales, and differing in colour and texture.

(2) The associated and interstratified shales contain *Diplograptus* and *Climacograptus*, and shales, seemingly of the same series, yield *Dicranograptus* at one outcrop, and *Dicellograptus* at another.

(3) The brachiopods, corals and crinoids obtained from the Grits present a mid or newer Silurian facies, with an admixture of older forms.

(4) The Grits seem to overlie normal *Dicellograptus-Dicranograptus* shales, but have not been seen interstratified with such shales.

(5) The Grits underlie the Kerrie Conglomerate north-west of Riddell.

Our conclusions are as follow:—

(i.) The Grits, with their associated shales, etc., represent a shallower water series than the normal Upper Ordovician graptolite shales.

(ii.) They are probably of Upper Ordovician age, and since they overlie *Dicranograptus* beds, are probably late Upper Ordovician.

(iii.) From (a) their resemblance in texture, etc., to that of Silurian rocks as at Springfield, and (b) the absence of unmistakably overlying Upper Ordovician rocks we think it probable that the Riddell Grits were formed towards the close of the Upper Ordovician, probably during differential movements, which closed the Ordovician, and ushered in the Silurian. In placing the Grits as Upper Ordovician, we emphasise their graptolite fauna more than the brachiopods and other forms. *Diplograptus* and *Climacograptus* range into the Lower Silurian, but *Glossograptus, Dicranograptus* and *Dicellograptus* do not. Still, the only graptolites found in undoubted Grits have been *Diplograptus* and *Climacograptus.*

IX.—Kerrie Conglomerate.

(a) Field Relations.

Messrs. Skeats and Summers[33] have drawn attention to the difficulty of understanding the relation of the Kerrie Conglomerate to neighbouring rocks. For descriptions of the Conglomerate reference should be made to their memoir or to Mr. Hart's paper. Messrs. Skeats and Summers[34] state that "it is probable that a line marking the western extension of the Conglomerate would indicate the junction between Upper and Lower Ordovician rocks in this area," and in another place mention[35] that the Conglomerate "overlies apparently unconformably shales from which no fossils were obtained." They state that the Conglomerate is in their opinion basal Upper Ordovician. In the absence of fossils any opinion was necessarily tentative. The shales are brown and light blue, and very rubbly. There are occasional narrow dark blue bands. In these respects they are unlike the Lower Ordovician shales with which we are acquainted, but closely resemble Upper Ordovician shales on Jackson's Creek. We had found that at the latter outcrops, graptolites occurred in the dark bands, and carefully splitting a dark band at Conglomerate Creek, we obtained several specimens of a *Diplograptus* resembling those found at other Upper Ordovician outcrops. At two localities further west similar graptolites were obtained. These shales cannot be referred to beds below the Upper Ordovician. The shales apparently underlie the Conglomerate, which outcrops further up the hills.

Messrs. Skeats and Summers also refer to Emu Creek, a locality to the north-east of the area discussed in this paper. They state:[36] "On the Emu Creek in Allot. 48a, Parish of Kerrie, another find of graptolites was made; Dr. Hall identified *Diplograptus foliaceus* and *Dicellograptus elegans*. The beds dipped at a high angle downstream in a south-easterly direction, and again the Kerrie Conglomerate occurs only to the west and northwest of these beds. A short distance upstream from the point where the graptolites occur the conglomerates occur in situ dipping downstream, and conformable with sandstones overlying them. Above this shales come in and further upstream conglomerates

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33. 4, p. 45.
34. Ibid. p. 14.
35. 4, p. 41.
36. 4, p. 41.

once more appear in force." They add[27] that "it would be possible to regard the conglomerates as unconformably and overlying the Upper Ordovician shales, or as being conformable and underlying the beds which contain the graptolites." They adopt as the more probable view "that there is one marked band of conglomerate repeated in Emu Creek by faulting or folding, and that it underlies the Upper Ordovician shales. Probably it forms the basal member of that series, and rests unconformably upon the Lower Ordovician series." At two localities where we observed the conglomerate coming almost to the water's edge in Emu Creek, it seemed to us to rest upon the upturned edges of shales, almost certainly the same as those which further downstream yield Upper Ordovician graptolites. At the second outcrop the shales were so nearly in contact with the conglomerate that we tried, though unsuccessfully, to clear the loose boulders and expose the junction. Our conclusion is that at Emu Creek, as at Riddell's Creek, the Kerrie Conglomerate is younger than Upper Ordovician graptolite shales.

(b) Age of the Kerrie Conglomerate.

The Conglomerate has been stated to consist of rounded boulders and pebbles of quartzite, and it would be difficult to imagine a more unpromising rock in which to search for fossils. That fossils occurred in it seemed at first probable, since Ba 73, near the mouth of Conglomerate Creek, refers to "a pebble from the conglomerate." It soon appeared that this fossil was most likely obtained from the Grits, which outcrop at this spot, but which were not recognised by the Geological Survey. In spite of the unpromising nature of the Conglomerate, we were successful in finding fossils in it. In fact, west of Conglomerate Creek, loose boulders of Conglomerate can be obtained which would be mistaken for Grit were it not that the matrix is shown in many instances. The fossils are the same brachiopod and crinoid fragments, and it seems probable that the Conglomerate here is composed partly of waterworn pebbles from the Riddell Grits. Pebbles can be obtained from the Conglomerate, which show every gradation of fineness shown by the Grits. Elsewhere the Conglomerate seems to have been derived mainly from the quartzose bands of the Upper Ordovician.

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27. Op. cit. p. 42.

Our conclusion is that the age of the Conglomerate depends upon the age of the Riddell Grits, which, as we have already stated pass under it, and in part at least, seem to have provided the material of which it is formed. We have set out the considerations which lead us to postulate a late Upper Ordovician age for the Grits, and it seems to us probable that the Conglomerate may be a basal Lower Silurian deposit. This would not be inconsistent with the enclosure of resorted material from it in Lower Silurian mudstones as reported from Springfield.[38] (See Figs. 2 and 3.)

X.—Tertiary Gravels.

Scattered throughout the district are deposits of river gravel. In many cases they have been metamorphosed by the action of the Newer Basalt flows which covered them, and show all gradations from a comparatively loose gravel, such as is found on the gold-fields, to a homogeneous quartzite, in which all trace of individual pebbles has been lost. The gradual change is well shown near the junction of Riddell's and Jackson's Creeks. The lowest gravels are hardly consolidated; above them is a conglomerate, while just below the basalt the rock is quartzitic. It is possible that isolated outcrops of this rock have been mistaken for Ordovician, and this may account for the strip of bed rock shown along Jackson's Creek on the Quarter Sheets, below the mouth of Watson's Creek. As far as we can see, gravel alone occurs in patches here.

The highest gravels are on the flanks of Hare's Hill, and would be about 1650 feet above sea level. Between this hill and Gisborne there are widespread sheets of gravel at levels from about 1350 to 1600 feet. Further south the levels are 1520 feet west of Mount Gisborne, 1400-1500 feet around the Glendoon Spur, about 1300 feet at Breakneck Hill on the Melton Road, and 1000 feet a mile further south. While we were endeavouring to reconstruct the earlier contours by means of the alluvial gravels, C. Fenner[39] had attacked the same problem by a consideration of river grades. We have availed ourselves of his results which, like ours, indicate the existence of an east and west fault, called by him the Gisborne Fault. This name might, we think, be with advantage altered to "Toolern Fault," as the fault is several miles south of Gisborne, while the fault which we have indi-

38. 4, p. 42.
39. 6, p. 266, 267.

cated as the boundary of Lower and Upper Ordovician, must pass right through the township.

XI.—Newer Volcanic.

It is not our intention to deal with these rocks in detail. On examination they will probably be found to present problems not indicated by a cursory inspection. Where the basalt flowed over the old water sheds, the covering is comparatively thin. In the valleys it is of considerable thickness, as is well shown between Gisborne and Dalrymple's and west of Lancefield Junction. Below the "Toolern Fault" the thickness is greater and bedrock is not exposed by the Toolern, Yangadook or Kororoit Creeks in the south of the district.

XII.—Summary.

1. Attention is called to the comparative neglect of a complex and interesting area within 30-40 miles from Melbourne.

2. The Geological Survey classification of rocks in the Gisborne district is set out, and a revised classification proposed, dividing Upper and Lower Ordovician, substituting the Kerrie Conglomerate (already recognised by Victorian geologists) for the Oolitic, and adding a new series, the Riddell Grits.

3. The physiography of the area is briefly touched on, and the influence of the Djerriwarrh Fault and the Newer Volcanic basalt flows indicated. An attempt is made to re-construct the main outlines of the pre-volcanic topography.

4. The distribution of Lower and Upper Ordovician rocks is described, and some account is given of their graptolite fauna. It is shown that the division between Lower and Upper Ordovician is a straight line running through Gisborne in a direction slightly east of north, and evidence is adduced to show that this line represents a fault which is indicated on the accompanying map as the Djerriwarrh Fault. The down throw is to the east, and the fault is pre-Newer Volcanic, but how much older is unknown.

5. A tentative recognition of three Upper Ordovician graptolite zones is proposed—

1. *Diplograptus-Didymograptus* zone (Lowest).
2. *Dicellograptus* zone.
3. *Dicranograptus* zone.

The probability of a higher zone is indicated. This division is set out only as a basis for further work.

6. The distribution of a series of grits, sandstones and shales, termed the Riddell Grits, is shown, and some account is given of their field relations and fossils. It is held that—

- (a) They overlie *Dicranograptus* shales (Upper Ordovician).
- (b) They underlie the Kerrie Conglomerate.
- (c) Their contained brachiopod and coral fossils indicate a mid or newer Silurian horizon, though some older forms are present. The presence in them of *Diplograptus* and *Climacograptus* indicates a greater age, and if the shales containing *Dicellograptus* belong to the series, that age must be Upper Ordovician. The suggested age is Upper Ordovician, near the close of the period.

7. The Kerrie Conglomerate is stated to overlie, unconformably *Dicellograptus* shales at Emu Creek, and *Diplograptus* shales and Riddell Grits north-west of Riddell. Fossils were found in the pebbles of the Conglomerate, similar to those obtained from the Riddell Grits, and the view is taken that it is in part formed from the Grit. The suggested age is basal Lower Silurian.

8. The Tertiary gravels are briefly mentioned, their metamorphism by the Newer Basalt described, and the existence of an east and west fault in the south of the district deduced from an abrupt change in the levels of the gravels, corroborated by a similar steepening of grade in the creeks along a line approximating to 37° 35′ S.

9. Acknowledgement is made of help received, and a bibliography of papers, etc., referred to, is appended.

XIII.—Acknowledgments.

Our thanks are due in the greatest measure to Mr Chapman, Palaeontologist of the National Museum, Melbourne. Not only has he devoted much time to the examination, and, where practicable, the identification of fossils, particularly from the Riddell Grits, but he has throughout assisted us with advice and kindly criticism. Mr. R. A. Keble, of the Mines Department, rendered us valuable assistance, especially in the physiographical section of the paper. Professor E. W. Skeats, D.Sc., of the Melbourne University, kindly read through the paper, and we have had the

value of his suggestions on several points in it. The bibliography sets out a list of the articles more directly referred to, but it is impossible to indicate, except in a general way, the use we have made of these papers, and of others not specified. The observations we have described are the results of between two and three years of field work, and the conclusions represent in all cases the joint opinions of the authors. The paper makes no pretence of finality. The area we have discussed is much too large, and its geology too complex to be treated of in a single paper, and the problems it presents will provide work for years to come. It is hoped that this paper may prove an introduction to a district till now geologically neglected. The beginning of the investigation—which has far outgrown our original intention—was due to a suggestion from Mr D. J. W. McHaffie, of "Colane," Gisborne.

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[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921].

Art. V.—*A Geologist's Notes on Water-Divining.*

By GRIFFITH TAYLOR, D.Sc., B.E., B.A.

(With Plate IV. and two Text Figures).

[Read July 8th, 1920].

In view of the widespread belief in Australia in the powers of the Water Diviner, the following personal experiences (followed by the authoritative opinions of others) should be of interest to members:—

On a recent visit to the Federal Capital Territory, I devoted several days to the question of water supply for the repatriated soldiers in the valley between the Ainslie-Majura ridge and the Black Mountain ridge.

The *general geology* is simple. The valley runs north and south, and consists essentially of Silurian shales and clay-slates covered by a variable thickness of recent alluvial. These shales are flanked on the west by the harder sandstones and quartzites of Black Mountain, which form a ridge about 800 feet above the plain. (See Text Figs. 1 and 2.)

On the east is a ridge of hard porphyry or tuff. These eruptive rocks are probably later than the sedimentary shales and sandstones. This porphyry constitutes Mount Ainslie and Mount Majura. The line of junction between the porphyry and the shale runs north and south except for a spur of porphyry, which forms the low ridge at Ainslie Post Office. These features are shown in a general fashion in the coloured map by D. J. Mahony and myself. (Report of Geological Reconnaissance, 1913.)

There is nothing unusual in the conditions in the Ainslie Valley, save perhaps that the unbroken rampart of hard rocks (see contours on figure 1) on each side indicates that the water supply will be fairly reliable if ordinary geological precautions are taken in sinking wells.

Here, as everywhere, a large portion of the water sinks underground through the porous surface soils, debris, gravel, talus and alluvium generally, until it reaches the solid impervious rock beneath. Both the formations here represented are of an impermeable nature, i.e., the solid shales and solid porphyry.

The water, on reaching this region, forms a more or less con-

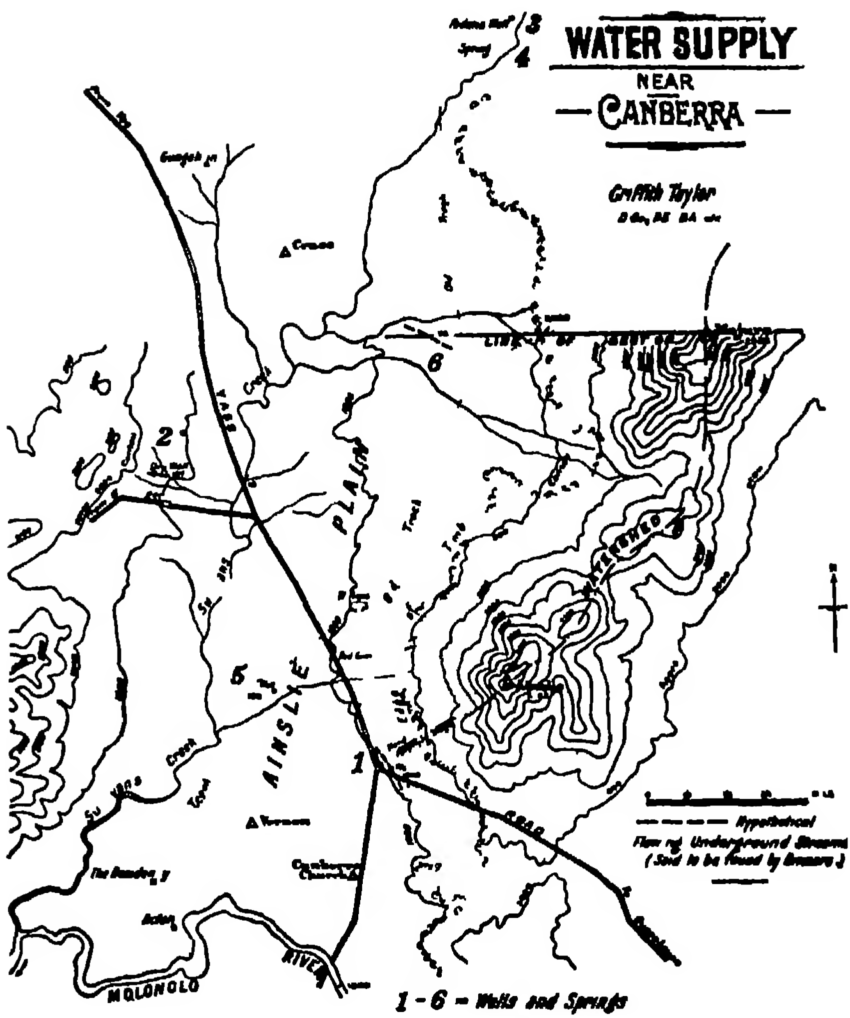
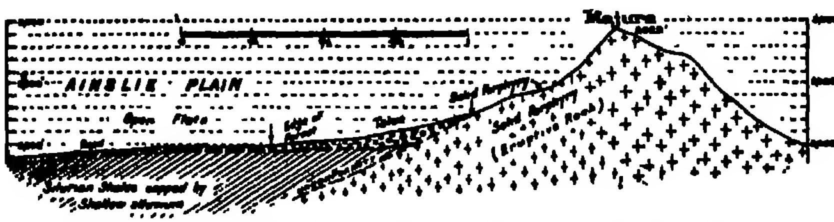


Fig 1

tinuous sheet Every filament of this sheet is always moving down the steepest grade The *water-table* (see Text Fig 2) differs from the surface of the ground in that the water is not confined to well defined channels though there may of course be underground gullies where the water sheet is thicker It is very important to understand this concept of the water table Almost every miner knows that in similar country he reaches the level where pumping is necessary at about fifty feet but he remains a believer in the water diviner s prowess in face of his common sense! The region under discussion receives about nineteen

or twenty inches of rain a year, and this is ample to keep the underground waters fresh and flowing. Wells are not usual in such wet regions with sparse settlement, for the few farmers find dams more convenient. But it is infinitely easier to find.



VERTICAL SECTION (WEST TO EAST) ACROSS THE EASTERN SIDE OF AINSLIE PLAIN.
SHOWING THE WATER TABLE ———
$\frac{\text{VERTICAL SCALE}}{\text{HORIZONTAL}} = \frac{8}{1}$

FIG. 2

a supply at Canberra than say in the Tarcoola district (S.A.), where there are, however, many more wells.

The drainage of the Ainslie Valley is normal, reaching the Molonglo by means of Sullivan's Creek, or by the creek from Ainslie (see Text Fig. 1). The slope of the main stream (Sullivan's) is very gradual, dropping only   feet between Peden's farm, and the Residency Track. The hill slopes rise fairly suddenly above the 2000 feet contour, and below Majura, there are slopes of 33° The 2000 feet contour is shown in the plan, and may be taken as near the boundary of the Plain.

I investigated the following wells:—

No. (1) Well at Ainslie.
„ (2) Well in the West.
„ (3) Peden's well in the North.
„ (4) Peden's spring in the North
„ (5) The Engineer's shaft, north of Vernon.
„ (6) The site of a well, east of Crace.

These numbers appear on the map, Text Fig. 1.

(1) *The Well at Ainslie.*

Early in 1919 the district was short of water, and there was the usual recrudescence of water diviners. Mr. D——— gave his assistance to the owner of Ainslie Well (1). The latter kindly furnished me with full details of the diviner's work, which differs in no particular from the usual procedure.

The diviner used a forked rod[1] of "red gum," cut from the adjacent clump to the north (see map). He tested for water hereabouts, but found none. Then he walked south (see Fig. 1), and the fork began to dip 200 feet away from the old clump. He followed the "flowing stream" towards the old Post Office. It crossed the spur of undecomposed porphyry shown in Plate iv., Fig. 1, and traversed the yard. Here it was said to be confined to a belt of about 100 yards wide, and the diviner advised the owner to sink in the middle of the belt, just where it left his property.

The owner, with great energy and perseverance, sank his well through the decomposed zone fringing the porphyry bluff. I measured the rocks roughly as follows:—

Top	18 inches grey soil
	6 inches ironstone gravel.
	24 inches clay.
	6 inches coarse gravel.
	18 inches clay.
	12 inches gravel.
	12 inches clay.
	6 inches gravel
	48 feet decomposed porphyry-tuff.
Bottom	8 feet less decomposed tuff.
Total	64 feet.

A vertical "vein," or crack, with pug, was some assistance in excavating for the lower thirty feet. Great credit is due to the owner for his energy, for the work occupied his spare time for eight months. At fifty-six feet some water came in, giving fifteen gallons by the morning. At sixty-four feet, water was "bubbling in." (See Plate IV., Fig. 2.)

The well supplies from 400 to 800 gallons in twenty-four hours, as far as we could roughly measure it. A 400 gallon tank is filled, and a luxuriant garden is the result of the well.

The diviner had estimated that water would occur about fifty-six feet. The method (as I was told in another case) probably being to *divide the width of the belt by two, and change yards into feet!* i.e., $\frac{112 \text{ yards}}{2}$ = depth in feet.

1 The forked rod used had a butt $2\frac{1}{2}$ inches long and $\frac{1}{2}$ inch diameter. Each leg was 16 inches long and about $\frac{1}{8}$ inch diameter

Conclusions: The owner obviously reached the water-table, which here is determined by the lower boundary of permeable (decomposed) tuff. He has a poor catchment on the slope of the ridge shown in Fig. 1, where the average rainfall is about twenty inches. It is fair to state that the conditions were not very favourable for water, and that one could choose a hundred better places within half a mile. However, they were not on his property!

The chief geological interest in this example lies in the course of the "flowing *stream*." I have already mentioned that definite streams are not to be expected under the conditions obtaining in the Ainslie Valley.

Moreover, the drainage underground must conform with the surface contours in general In this case the hypothetical "stream" runs perpendicular to a well-defined slope, and right through a ridge of porphyry tuff, whose undecomposed outcrop is visible at the surface! (See line on Plate figures.)

I am of the opinion that as the water table can be reached at from twenty to fifty feet anywhere in this flat, there is no evidence that the diviner exhibited any occult power in this case. Moreover,an analysis shows that the well water is distinctly not potable, while the "flowing *stream*" supplying the well can only be a portion of a sheet of extreme tenuity.

It is of psychological interest that everyone had heard of the Ainslie success (No. 1 on Text Fig. 1), whereas few knew of the next case, that of the well about one mile to the north-west (No. 2 on Text Fig. 1).

No 2 Well.

The same arid conditions early in 1919 led another settler on the other side of the valley to engage a diviner. Mr T——— carried out the work. He chose a ridge between two gullies, considerably above the general level of the valley (see map). Here the outcrop was of Silurian clay-slate, with very little surface soil.

The diviner mapped out a "flowing stream," which ran east and west, and again was not in accord with the very definite slopes of the valley.

The "stream" ran from one gully to another, and the owner was advised to sink near the crest of the traverse. He went down thirty-two feet through somewhat decomposed shale, and then about twenty-five feet in hard shale. Apart from a few

damp patches, he saw no water. He "jumped" another twelve feet below the shaft with no result. So that a total of about seventy feet failed to corroborate the diviner. The latter had stated that he was able, by the varying "pressure" on the fork to tell where the water was nearest the surface. This was not in the *gully*, as one would suppose, but on the ridge farther east *on the course* of the "flowing stream." One must therefore postulate that his stream flows upstream, as well as along contours!

It is amusing to note that the settler was drawing water all the time of sinking his own well from the Engineer's shaft (5 on Fig 1) put down in the middle of the flat, about one and a-half miles to the south. The latter was, I believe, sunk without any assistance from a diviner (or geologist!) merely to find out the character of the strata. It penetrated the water table, and so has had a good supply ever since (The mouth of this shaft is thickly screened by large ferns.)

I investigated two wells in Mr. Peden's property to the north of the Repatriation areas. The further well (No. 3) was presumably sunk in a very dry season, possibly forty years ago. It had not been needed at a later date, and was filled in when I saw it.

About a quarter of a mile to the south was a spring, which Mr. Peden had floored with large stones. (No. 4 on Fig. 1.) Here he was able to get a plentiful supply for his stock. In very wet seasons it flowed away to the creek, but usually the water was run into a trough by means of a small pump.

This spring is a striking proof of the large water supply in the valley, for it occurs in a flat at a considerable distance from any slopes.

In conclusion, I should like to quote from the "English Mechanic," 11th April, 1913. At Guildford (England) six diviners gave an exhibition before a committee of well-known scientists over ground chosen some time before by the latter.

Site No. (1) (Chosen over a spring): "Most of the diviners missed it."

Site No. (2) (Chosen over a sewer): "All missed it."

Site No. (3) (Grass-covered top of a reservoir): "To see water-diviners walking about a few feet above a mass of water —running water, too—and not being able to detect it, was exquisitely funny." ("Daily Mail" report.)

I believe that much depends on the elasticity of the fork. It is of the nature of a spring, and I feel sure that if the diviner's

hands were fixed so that they *could not move,* outwards or inwards (while still remaining in actual contact with the fork) that many of the results would be unobtainable. It is of interest that I was told of a diviner who was unable to divine after the *loss of his thumb!* This, to me, means that he could not hold his fork firmly.

Three later quotations will surely convince even the most sceptical that the matter concerns the psychologist as an interesting example of "mind influencing matter" (i.e., the muscles), rather than the geologist or farmer.[2]

(*a*) The Commission for Water Conservation and Irrigation in Sydney reports (10th June, 1920).—

"Of fifty-six bores located with the aid of the divining rod seventy per cent. were successful, while, of ninety-six bores sunk without the aid of the divining rod, eighty-seven per cent. were successful. In view of these practical results, it has been decided, after careful consideration, not to make further tests."

(*b*) The Government Geologist of South Australia (L. Keith Ward) reports (5th November, 1914) *inter alia*:—

"It should be apparent to all that the finding of water at a spot 'indicated' by the divining rod constitutes no proof at all of the efficacy of the means of locating the water. It is not sufficient to test only the spots 'indicated.' The area wherein 'no indications' are given by the rod or machine must also be adequately tested before any judgment can be formed. The only test of this character that has, to my knowledge, been carried out in South Australia, is one that was conducted many years ago, on behalf of the South Australian Government, by Mr. T. Parker, in order to test the claims of a man who professed to be able to locate water with the divining rod. The results of this test showed that water existed *throughout* the area in which the experiments were carried out, both at the spots 'indicated,' and in intermediate positions *where no 'indications' were given.*"

(*c*) Finally, the American Geological Survey in 1917 published a report (by A. J. Ellis) containing this summary of the whole matter:—

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2 To my mind this opinion is confirmed by the *fact* that the divining rod has also been used in all good faith in the past; to detect or locate (1) Ores, (2) Treasure, (3) Lost Landmarks, (4) Criminals, (5) Strayed Animals: and even to cure diseases and analyse personal character (vide Ellis *infra*).

"It is difficult to see how for practical purposes the entire matter could be more thoroughly discredited. To all enquiries the U.S. Geological Survey gives the advice not to expend any money for the services of any 'water witch,' or for the use or purchase of any machine or instrument for locating underground water."

I have to thank the Federal Surveyor-General for the loan of the two maps, prepared partly from my own sketch maps.

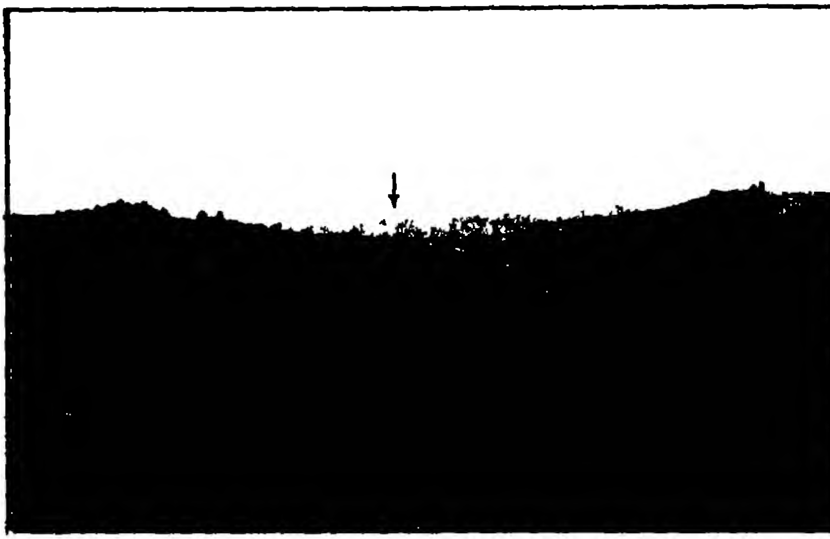

FIGURE 1

Photo (looking south) showing the locale and direction of the underground stream (broken line) as traced by the diviner It flows (?) through the outcrop of hard porphyry (at right angles to the dip of the slope) to No 1 well The top of the windmill is just visible below the arrow

FIGURE 2

Photo (looking north) of No 1 well at Ainslie It is sunk in talus and rotten porphyry for 64 feet, and gives 600 gallons per diem (The windmill was made by the owner of oil drums and Ford car gears) Notice the outcrop of solid porphyry on the left (sky line), through which the diviner traced (?) the stream whose course is indicated by the broken white line Part of Mount Ainslie shows on the right

[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921].

Art. VI.—*A Revision of the Australian Cicadidae. Part I*

By HOWARD ASHTON.

[Read July 8th, 1920].

This family, so prominent in the entomology of Australia, seems to me now to be entitled to some revision so far as Australian species are concerned. The need arises from the fact that errors have crept in to classifications in the past, and because, since the last contribution to the literature of the family which covered the whole ground (I am speaking of Australia), Goding and Froggatt's valuable Monograph (Proc. Linn. Soc. N.S.W., 1904), many new species have been named, and several old ones more closely determined. It is unfortunate, and says little for the patriotism of collectors here, and for the Governments which subsidised Swedish, German and other foreign expeditions to collect material for foreign museums, that many of our types are not available here. The same remark applies, of course, to other branches of our fauna. If, when specimens are sent out of the country to foreign experts, duplicates only were despatched, our collections would be in a better state to-day than they are. The types of our Cicadas are thus scattered, many being in the British Museum. Some, of course, are in our own museums and collections. Many of the types of Goding and Froggatt are, fortunately, here in Australia. Some are in the Macleay Museum, Sydney, but some which were there are now missing. There are my own types in the museums of Sydney, Melbourne and Adelaide, and in my own collection. In this latter, too, are a number of authentic determinations by Mr. W. L. Distant, who has been good enough on several occasions to examine material I have sent him. I pass over some determinations by Walker in the Melbourne Museum, as they are, in several cases, obviously and completely contradictory and wrong.

I find reason, here and there, to traverse the determinations of former writers. It is unnecessary to state that I do so with regret, and only in the cause of what all workers must seek—scientific accuracy. Mistakes will creep in to any man's work, and, until everything is clear to mankind, will continue to creep in, and what one believes to be the truth, he must, in all humility,

stand by. When I do venture to differ from such an authority as Mr. Distant, and it is very rarely, it is with a deep sense of the obligations I myself and other workers must acknowledge to the greatest living authority on the family. Where I differ from Messrs. Goding and Froggatt, also, I do so with the respect due to those who have done pioneer work in their Monograph.

I have included New Zealand in the ground covered by this revision, because the few cicadas there are obviously descendants of Australian ancestors, all belonging to our greatest and most widely diffused genus, *Melampsalta*. With the exception of one or two from Lord Howe and Norfolk Island, the rest are from the continent itself, or from islands so close to it that they may be regarded as portions of the mainland. My system of references comprises all distinct synonyms, descriptions, and especially figures. In some cases, where I have not seen an authentic specimen of a species, I publish the original descriptions. Several new descriptions and generic divisions are also included. Where types are available, I have named the collections in which they are.

Sub-family CICADINAE, Dist.

This family contains the largest and most conspicuous of the Australian Cicadas It is distinguished by the cryptic disposition of the tympana, which are fully covered by a prolongation of the basal abdominal segmental walls. In some genera these covering processes are dilated into large horny sacs.

Division Polyneuraria, Dist.

Genus **Platypleura**, Amyot and Serville.

Type *P. stridula*, Linnaeus (Africa).

This genus, dominant in Africa, and widely spread from that continent across Asia to the Philippine Islands, is represented by one species in Australia. I do not, however, feel at all sure the evidence of Australian habitat is established.

Platypleura tepperi, Goding and Froggatt.

Platypleura tepperi, God and Frog. Proc. Linn. Soc. N.S.W., 1904, p. 568, pl. xvii, fig. f. 5 a.

Type, South Australian Museum, Adelaide, other specimens in the Macleay Museum, Sydney. *Hab.*—Northern Territory.

Division THOPHARIA, Distant.

Genus Thopha, Amyot and Serville.

Type *T. saccata*, Fabricius.

THOPA SACCATA, Fabr.

Tettigonia saccata, Fabr. Syst. Rhyn., p. 34, 9, 1803.
Cicada saccata, Guer. Mag. Zool., p. 80, pl. ccxxxviii., 1838.
Thopa saccata, Am. and Serv. Hist. Hem., p. 471, 1843; Frog. Aust. Ins., p. 348, fig. 154.

Specimens in all museum collections. *Hab.*—New South Wales.

THOPHA SESSILIBA, Distant.

Thopha sessiliba, Dist. Ann. Mag. Nat Hist., (6), ix., p. 314 (1892); id. Gen. Ins. fasc., 142, p 21, pl. 3, fig. 17, a, b, c, 1912.
Thopha stentor, Buckton. "Home University Magazine," Haslemere, i., p. 371, 1898.

Specimens in Macleay, Melbourne and Adelaide Museums, and in Coll. H.A. *Hab.*—Central Australia, Northern Territory (?), Queensland.

THOPHA COLORATA, Distant.

Thopha colorata, Dist. Ann. Mag. Nat. Hist. (1907), xx.. p. 411.

One specimen in Coll. H.A., two (mutilated) in Adelaide Museum. *Hab.*—North-Western Australia.

T. NIGRICANS, **Distant.**

Thopha nigricans, Dist. Ann Soc. Ent. Belg., 1910, p. 415.

Head pronotum, mesonotum, sternum, and legs piceous or black, abdomen, tympanal covers and opercula testaceous, tegmina and wings hyaline, talc-like, venation dark ochraceous, basal cell brownish-ochraceous, with a small hyaline spot at its lower extremity, and with its upper margins black. Base of head between eyes about as broad as medial length of vertex. Eyes strongly pedunculate, considerably passing anterior pronotal angles, anterior margins of vertex before front distinctly ridged, and diverging ridges between ocelli. Pronotum with four central carinations on anterior area, posterior margin strongly transversely striate, lateral margins of pronotum and

mesonotum, interior area of cruciform elevation, and posterior ridges of metatotum ochraceously pilose. Tympanal coverings very large and testaceously opaque, abdomen much shorter than expanse of tympanal coverings, above a little more than half their expanse, below about two-thirds. Apical segment above testaceously tomentose. Long 42 mm., exp. teg., 128 mm. *Hab.*—North Queensland.

Allied to *Thopha sessiliba,* Dist. by pedunculate eyes, differing by shorter and broader abdomen, more concave posterior margin of metasternum, and black head and thorax.

There are two specimens in Coll. H.A., which I take to belong to this species.

SYNOPSIS OF SPECIES.

T. saccata. Tympanal sacs deep reddish-chestnut, eyes not sessile.

T colorata Tympanal sacs orange-yellow, abdomen very narrow. Eyes sessile.

T. sessiliba Abdomen marked with white tomentum. Eyes sessile. Colour generally yellow.

T nigricans. Tympanal sacs testaceous, head and thorax black Eyes sessile.

Genus **Arunta**, Distant.

Type *A. perulata,* Guerin.

ARUNTA PERULATA, Guer.

Cicada perulata, Guer. Voy. "Coquille," Zool. ii, p. 180, pl x., fig. 5, 5a, 1830.

Henicopsaltria perulata, God. and Frog. Proc. Linn Soc., N.S.W., 1904, p. 575.

Arunta perulata, Dist. Syn Cat. Hom. Cicad., 1906, p. 27; id. Gen. Ins. fasc., 142, p. 21, pl 2, figs. 18, a, b, c, 1912.

In all Museum Collections *Hab.*—Sydney, Coastal New South Wales and Queensland.

ARUNTA INTERCLUSA, Walker.

Thopha interclusa, Walk. List. Hom. Suppe, p. 5, 1858; id. List. Hom. iv., 1852, pl. 1, fig. 6.

Henicopsaltria interclusia, Stal. Berl. Ent. Zeit., x., p. 171, 1866.

Arunta interclusa., *Dist.* Syn. Cat. Hom. Cicad., 1906, p. 27.

Arunta flava, Asht. Rec. Aust. Mus. Sydney, ix., i., p. 76, pl. vii., figs 1 and 2, 1912.

Specimens in Sydney and Adelaide Museums, and Coll H.A.

Hab.—Queensland.

ARUNTA INTERMEDIA, n. sp.

Head greenish-yellow, with margins of front, fascia between eyes, including vertical margins and region of ocelli, and narrow fascia on posterior margin, black. Pronotum reddish, a central stripe (narrower posteriorly, and surrounded by a black line), yellow, posterior margin yellowish testaceous. Mesonotum, with two small anterior obconical spots (margined with yellow), and a broad fascia on each side, inwardly much broken, deep brown, a black central longitudinal line, and spots before cruciform elevation.

Abdomen light brown, with a spot of white tomentum on second segment, a few black transverse markings on apical segments. Tympanal sacs testaceous, devoid of tomentum, abdomen beneath, and sternum also bare of the usual white "flour." Tegmina and wings talc-like, venation from pale to dark fuscous, basal venation of wings whitish, first two anastomoses to tegminal apical areas palely infuscated

Long.—Male, 31 mm.; female, 33 mm. Expanse of tegmina, male, 103 mm ; female, 100 mm.

Hab.—Cape York, N. Queensland.

One male and two females in Coll H.A , Coll by H. Elgner, 1906.

SYNOPSIS OF SPECIES.

A. perulata. Body robust, dark chestnut to piceous, anal plate beneath testaceous with central black line. Much powdered with white.

A. intermedia. Body not so robust, brown, anal plate beneath all deep brown. Not powdered with white.

A. interclusa. Body yellow with black markings, powdered with white, anal plate beneath testaceous. Tegmina unmarked.

Division CYCLOCHILARIA, Distant.

Genus **Cyclochila**, Amyot and Serville.

Type *C. australasiae*, Donovan.

CYCLOCHILA AUSTRALASIAE, Don.

Tettigonia australasiae, Don. Ins. New. Holl. Hem., pl. II., fig. 1 (1805).

Cicada olivacea, Germ. Thou. Ent. Arch. ii., p. 1, 1830.

Cyclochila australasiae, Am. and Serv. Hist. Hem., p. 470, fig. L, 1880; Frog., Aust. Inst., p. 349, pl. xxxii., figs. 1 1843; McCoy, Prodr. Zool. Vic., Dec. v., p. 57, pl. i., to 8.

Specimens in all Museums. *Hab.*—New South Wales, Victoria.

CYCLOCHILA AUSTRALASIAE, var. SPRETA, God. and Frog.

C. australasiae, var. *spreta*, God. and Frog. Proc. Linn. Soc. N.S.W., 1904, p. 570.

This variety is distinguished by the black fascia across vertex of head, black longitudinal fasciae on pronotum and mesonotum, and black abdomen.

Specimens in all Museums. *Hab.*—New South Wales, Victoria.

CYCLOCHILA VIRENS, Distant.

Cyclochila virens, Dist. Entomologist, 39, 1906, p. 148.

Cyclochila laticosta, Asht. Proc. Roy. Soc. Vic., 1912, ii., p. 221, pl xlix., figs. 1a, b.

Specimens in Coll H A., and in Adelaide Museum. *Hab.*—Kuranda, Queensland.

SYNOPSIS OF SPECIES.

C. australasiae. Costa moderately broad.

C. virens. Costa immensely dilated.

Genus **Psaltoda**, Staal.

Type *P. moerens*, Germar.

PSALTODA MOERENS, Germ.

Cicada moerens, Germ. Silb. Rev. Ent., ii., p. 67, 1834; McCoy, Prodr. Zool. Vic., Dec. v., p. 53, pl. l., fig. 1, 2 (1880).

Psaltoda moerens, Stal. Ann. Soc. Ent. Fr. 4, i., p. 614, 1861; Frog., Aust. Ins., 1907, p. 349, fig. 155

In all Museums. *Hab.*—New South Wales, Victoria, South Australia, Tasmania.

PSALTODA ARGENTATA, Germar.

Cicada argentata, Germ. Silb. Rev. Ent. ii., p. 66, 1834.
Psaltoda argentata, Stal. Ann. Soc. Ent. Fr., 4, i., p. 614, 1861.
Cicada plaga, Walk. List. Hom., i., p. 109, 1850.
In all Museums. *Hab.*—New South Wales.

PSALTODA PICTIBASIS, Walker.

Cicada pictibasis, Walk. List. Hom. Suppl., p. 31, 1858.
Psaltoda pictibasis, Stal. Ofv. Vet. Akad, Forh, 1862, p. 483.
Specimen in Macleay Museum, Sydney. *Hab.*—Queensland.

PSALTODA AURORA, Distant.

Psaltoda aurora, Dist. Trans. Ent. Soc. Lond., 1881, p. 644. id. Gen. Ins. Fasc., 142, p. 23, 1912, pl. 3, fig. 20 a, b, c.
Macleay Museum, Coll. H A. *Hab.*—Queensland.

PSALTODA ADONIS, Ashton.

Psaltoda adonis, Asht. Proc. Roy. Soc. Vic., xxvii., i, p. 13, pl. ii., figs. 3 a, b, 1914.
Types in Australian Museum, Sydney. *Hab.*—Queensland.

PSALTODA FLAVESCENS, Distant.

Psaltoda flavescens, Dist. Ann. Mag. Nat. Hist., 6, x., p. 55, 1892.
Specimens in Macleay Museum, Sydney, determined by Goding and Froggatt. *Hab.*—New South Wales.

PSALTODA FUMIPENNIS, Ashton.

Psaltoda fumipennis, Asht. Proc. Roy. Soc. Vic., ii., 1912, p. 222, pl. xlix., fig. 2 a, b.
Type, Coll. H.A. Specimen in South Australian Museum, Adelaide. *Hab.*—Northern Territory (?), Queensland (?).

This species is of doubtful habitat. It was described from two male specimens received from F. P. Dodd, and there seemed some uncertainty as to whether it came from Port Darwin or Kuranda. I think, however, that it is a Queensland species.

PSALTODA HARRISI Leach

Tettigonia harrisii Leach Zool Miscell p 89 pl xxxix fig 2 1814
Cicada dichroa Boisd Voy Astrolabe p 613 pl x fig 7 1832
Fidicina subguttata Walk List Hom i p 95 1850
Psaltoda harrisi Stal Ann Soc Ent Fr 4 i p 614 1861

PSALTODA CLARIPENNIS n sp

The greenish species named as a variety by Goding and Froggatt is I feel sure worthy of specific rank I sent one of these to Mr Distant some years ago and he determined it as a variety of *P harrisi* But there are in all the specimens I have seen structural differences which seem to me sufficient grounds for elevating it into specific rank The abdomen in *P harrisi* is very much longer than the head and thorax together in this species it is about the same length The head of *P harrisi* is relatively narrower In *P harrisi* again the posterior edge of posterior pronotal margin is straight in this species this edge is excavated very distinctly in the centre The face of *P harrisi* is less globose The opercula of this lighter species meet in the centre those of *P harrisi* do not The rostrum of *P harrisi* reaches the apices of the hind coxae that of this species barely reaches the bases I therefore propose for this species the name *Psaltoda claripennis* The habitat is Queensland

Long male 28 mm female 24 mm expanse of tegmina male 84 mm female 84 mm

PSALTODA INSULARIS Ashton

Psaltoda insularis Asht Proc Roy Soc Vic 1914 pt i p 14 pl ii fig 4 a b

Type in Australian Museum Sydney *Hab*—Lord Howe Island

SYNOPSIS OF SPECIES

A Abdomen black above

P moerens With hairy spots on sides of abdomen tegmina and wings deeply apically infuscated Thorax black above

P. argentata. With hairy spots on sides of abdomen, tegmina faintly infuscated on first two anastomoses. Thorax black above.

P. harrisi. With hairy spots on abdomen. Tegmina and wings immaculate. Thorax black above, much smaller than preceding species.

P. pictibasis. With hairy spots on abdomen. Tegmina with first three anastomoses infuscated. Thorax ferruginous.

P. insularis. With hairy spots on abdomen, tegmina not infuscated, thorax black and yellow.

B. Abdomen above reddish, yellowish or testaceous.

P. aurora. Tegmina with first two anastomoses infuscated. First abdominal segment broadly marked with black, rest reddish yellow. Thorax black and yellow.

P. flavescens. Tegmina with first two anastomoses and tips of longitudinal veins infuscated. Abdomen above pale castaneous, with black segmental marginal markings. Thorax more or less castaneous.

P. adonis. Tegmina with all anastomoses, and tips of longitudinal veins infuscated Abdomen above more or less luteous brown. Thorax green.

P. fumipennis. Tegmina and wings with broad apical infuscations. Abdomen yellow. Thorax green.

P. claripennis. Tegmina and wings immaculate. Abdómen castaneous, with black marginal segmental markings. Thorax green, marked with piceous and brown.

Note.—Goding and Froggatt describe (Proc. Linn. Soc. N.S.W., 1904, p. 589) *Psaltoda plebeia.* In the Macleay Museum there are a number of specimens, one of which is marked "Zipa, on locust trees." Two of these have been labelled as the types of *P. plebeia,* God. and Frog. The species is, as a matter of fact, *Cicada plebeja,* Scop., of the Mediterranean littoral. In one instance the usual chestnut colour of the pronotum has been replaced by yellow.

Genus **Neopsaltoda,** Distant.

Type *N. crassa,* Distant.

NEOPSALTODA CRASSA, Dist.

Neopsaltoda crassa, Dist. Ann. Soc. Ent. Belg., 1910, p. 415; id., Gen. Insect. fasc. 142, p. 24, pl. 4, fig. 21 a, b, c, 1912.

Hab.—Queensland.

I have not seen this species, but the figure in the "Genera Insectorium," should make it easy to identify when it does appear in museum collections.

Anapsaltoda, n. g.

Head not quite as long as pronotum, including eyes broader than base of mesonotum, eyes very sessile, front not as prominent as in *Psaltoda*. Posterior pronotal margin very broad, breadth equal to half the length of pronotum. Head and pronotum together about equal in length to mesonotum (excluding cruciform elevation) Tympanal coverings a little convex. Abdomen longer than thorax and head. Rostrum reaching apices of hind coxae. Opercula broad, convex, rounded posteriorly, overlapping interiorly. Abdomen beneath flattened and sharply depressed toward apex. Tegmina broad, acute at apices.

Type *A pulchra*, Ashton

ANAPSALTODA PULCHRA, Ashton.

Psaltoda pulchra, Asht. Proc Roy. Soc. Vic., 1911, ii., p. 222, pl. 1., figs 3 a, b; Dist Gen Insect. 142, p. 23 (1912).

Hab.—Queensland

One specimen, the type in Coll. H.A.

Genus Henicopsaltria, Stal.

Type *H. eydouxi*, Guerin.

HENICOPSALTRIA EYDOUXI, Guer.

Cicada eyedouxii, Guer. Voy. "Coquille," Zool. II., p. 181, 1830.

Henicopsaltria eydouxii, Stal. Berl. Ent. Zeit., x., p. 171, 1866; Frog, Aust Ins., p. 250, fig. 156, 1907.

Specimens in all Museums. *Hab.*—New South Wales, Queensland.

HENICOPSALTRIA KELSALLI, Distant.

Henicopsaltria kelsalli, Dist. Ann. Soc. Belg., 1910, p. 416.

Melbourne and Adelaide Museums, and Coll. H.A. *Hab.*—North Queensland.

SYNOPSIS OF SPECIES.

H. eydouxi. Opercula pink. Tegmina with apical and subapical infuscations.

H. kelsalli. Opercula black. Tegmina unspotted.

Arenopsaltria, n. gen.

I have ventured to separate out from the genus *Henicopsaltria* those members having the head and thorax deeply granulated. Another common difference is that the abdomen, which is broader in *H. eydouxii*, Guer., and *H. kelsalli*, Dist., than the thorax, is in these species, the same width. These characters are not the only differences. The wings of the three species *fullo*, Walk., *nubivena*, Walk., and *pygmaea*, Dist., are relatively very much shorter than those of the typical *Henicopsaltria*. And the second abdominal segment of *Henicopsaltria* is much longer than that of the proposed new genus. There are other and minor differences which workers in the family will notice.

Type *A fullo*, Walker.

Arenopsaltria fullo, Walk.

Fidicina fullo, Walk. List. Hom i, p 96, 1850

Henicopsaltria fullo, Stal Berl. Ent. Zeit x, p. 171, 1866; Dist. Gen. Ins, fasc 142, p 24, pl. 4, fig. 22 a, b, c.

Specimens in Sydney Museum, and in Coll H A. *Hab.*—Western Australia

Arenopsaltria nubivena, Walker.

Fidicina nubivena, Walk List. Hom. Suppl., p. 17, 1858.

Henicopsaltria nubivena, Stal. Berl. Ent. Zeit., x., p. 171, 1866; Asht., Mem. Nat Mus. Melb., 1912 (4), pl. iv., figs. K 1. 2, p. 24, 1912.

Specimens in Adelaide, Macleay and Melbourne Museums, and in Coll. H.A. *Hab.*—South Australia, Victoria, Tasmania.

Arenopsaltria *pygmaea*, Distant.

Henicopsaltria pygmaea, Dist. Ann. Mag Nat Hist. 7, xiv., p. 303, 1904.

I have not seen this species, and the type is not in Australia, and therefore I append Distant's description:—

Body ochraceous brown, abdomen castaneous. Pronotum with central ochraceous line, on each side of which is a narrow black fascia extending from anterior margin to near middle *Mesonotum* with two obscure central obconical spots on anterior margin, cruciform elevation ochraceous. Abdomen above with the

following greyish-white markings:—A small spot at inner angle of each tympanal covering, a broad anterior fascia (broken centrally) to second segment, and the anterior margin of anal segment. Tegmina and wings talc-like, venation ochraceous, tegmina, with the following fuscous spots:—One on each longitudinal vein to third ulnar area, each side of the transverse veins at apices of ulnar areas, and one at the apex of each longitudinal vein to apical areas Head, pronotum and mesonotum granulose, rostrum reaching posterior coxae, tympanal coverings prominent and finely transversely striate, abdomen finely pilose, opercula rounded, not extending beyond the anterior margin of the first abdominal segment. Tegmina only a little longer than body.

Long Corp. 14 mm., exp teg. 39 mm.

Hab—S W. Australia.

Allied to *H. fullo,* Walk, but very much smaller.

ARENOPSALTRIA UNICOLOR, n. sp.

Body above and below concolorous, a dull yellowish-brown, except for the following browner and darker markings: Vertex of head between eyes, obscure linear fasciae, enclosing central paler stripe on pronotum, posterior pronotal margin, and posterior abdominal segmental margins; beneath, facial sulcus, apex of rostrum, and opercula. Tegmina hyaline, veins at bases of apical areas, except 8th, more or less infuscated Costa and venation on basal half ochraceous, darker on apical half, basal membrane yellow; wings with venation on basal half ochraceous, darker on apical half.

This species apparently lacks the white tomentum so prominent in the three other species of this genus It may also be easily distinguished by the unicolorous body, and the less heavily infuscated tegmina.

Long, male 23 mm.; expense of tegmina, 67 mm.

Hab.—Perth, West Australia. Coll. by Mr. G. H. Hardy. Type in Australian Museum, Sydney.

SYNOPSIS OF SPECIES.

A. fullo. Abdomen marked with white as follows:—One interrupted band across second abdominal segment.

A. nubivena. Central white spot, bisected in centre on dorsum of first and second abdominal segments, spot on each side, behind tympanal covers, and whole of last segment.

A. pygmaea. Spot at inner angles of tympanal covers, broken anterior lateral fascia to second segment, and anterior margin of last segment.

Division CICADARIA, Distant.

Genus **Macrotristria**, Stal.

Type *M. angularis*, Germar.

MACROTRISTRIA ANGULARIS, Germ.

Cicada angularis, Germ. Silb. Rev. Ent. ii., p. 68, 1834.
Fidicina angularis, Walk. List. Hom, i., p. 78, 1870.
Macrotristria angularis, Stal Ofv. Vet Akad. Forh., p. 714, 1870; Frog, Aust. Ins, p. 350, fig 157, 1907.
In all Museums. *Hab*—New South Wales, Queensland.

MACROTRISTRIA THOPHOIDES, Ashton.

Macrotristria thophoides, Asht Proc. Roy Soc. Vic, i., p 13, 1914, pl. ii., fig. I. a.

Type specimen, one female in Coll H.A. Male more darkly marked, and apparently more typical, in the South Australian Museum. *Hab.*—North-Western Australia.

MACROTRISTRIA HIEROGLYPHICA, Goding and Froggatt.

Cicada hieroglyphica, God. and Frog. Proc Linn Soc. N S.W., 1904, p. 581.
Rihana hieroglyphica, Dist. Syn. Cat. Hom Cicad., p 38, 1906.
Specimens in Macleay, Coll. H.A., and Adelaide Museum. *Hab.*—North-West Australia, Northern Territory.

MACROTRISTRIA GODINGI, Distant.

Macrotristria godingi, Dist. Ann. Mag. Nat. Hist., 7, xx, p. 412, 1907; id. Gen. Ins. fasc. 142, p. 26, 1912, pl. iii., fig 23 a, b, c.

This species is only familiar to me by the illustration in the "Genera Insectorum," and the description in the "Magazine of Natural History." The only difference I can see between it and *M. hieroglyphica*, God. and Frog., is that the latter is without the yellow band on the abdomen shown in Distant's figure. *Hab.*—North-West Australia.

MACROTRISTRIA SYLVARA, Distant.

Cicada sylvara, Dist. Trans. Ent. Soc. Lond., p. 591, pl. xvi., fig. 1 a, b, 1901.

Macrotristria sylvara, Dist. Syn. Cat. Hom. Cicad., 1906, p. 31.

Cicada sylvana, God. and Frog. Proc. Linn. Soc. N.S.W., 1904, p 580.

Macleay and South Australian Museums. Coll H.A. *Hab.*—Queensland

MACROTRISTRIA NIGRONERVOSA, Distant.

Macrotristria nigronervosa, Dist. Ann. Mag. Hist., 7, xiv., p. 329, 1904

Head, pronotum and mesonotum ochraceous, head with face castaneous, ornamented with a piceous central fascia, and an oblique ochraceous spot on each side of base; the area of ocelli, inner margins of eyes, and narrow basal margin black. Pronotum with two very small sub-basal central black spots. Mesonotum with two central obconical spots on anterior margins black, each spot with a small ochraceous spot, the anterior margins on each side of these spots also narrowly black. Abdomen above black, posterior segmental margins narrowly ochraceous, margin of sixth segment, base and apex of anal segment, broadly ochraceous. Body beneath and legs ochraceous. anterior and intermediate tibiae and tarsi castaneous, body more or less greyishly pilose. Tegmina semihyaline, venation fuscous, basal cell, costal membrane and costal area ochraceous, transverse veins at apices of first, second, third and fourth ulnar areas more or less piceously infuscated, and a small fuscous spot on each longitudinal vein (excluding the uppermost) to apical areas. Wings semihyaline, venation ochraceous, apically fuscous, base narrowly ochraceous. Face very globose and prominent, head, including eyes, wider than anterior angles of pronotum, rostrum reaching posterior coxae. Long, female 36 mm., exp. teg. 95 mm. *Hab.*—North Queensland

Allied to *M. intersecta*, Walk., from which it differs by the more prominent face, spotted tegmina, different colour, markings, etc.

This species is in none of the collections here. The above is the original description.

MACROTRISTRIA DODDI, Ashton.

Macrotristria doddi, Asht. Proc. Roy. Soc. Vic., ii., p. 223, pl. 1., 5 a, b, 1912.

Type specimen and two co-types, all males, in Coll. H.A. *Hab.*—Doubtful; either North Queensland or Northern Territory.

MACROTRISTRIA INTERSECTA, Walker.

Fidicina intersecta, Walk. List. Hom., i., p. 97, 1850.

Fidicina internata, Walk. id. loc., p. 98.

Fidicina prasina, Walk id. loc , p. 100.

Cicada intersecta, God. and Frog. Proc. Linn. Soc. N.S.W., p. 584, 1904.

Cicada sylvanella, God. and Frog Proc. Linn. Soc. N.S.W., p. 582, 1904.

Macrotristria intersecta, Dist. Syn. Cat. Hom. Cicad , p. 32, 1906; id. Gen. Insect. 142, p. 26, 1912.

Hab.—Queensland, Northern Territory.

Specimens in Melbourne, Macleay, Sydney and Adelaide Museums, and Coll H.A.

MACROTRISTRIA EXTREMA, Distant.

Cicada extrema, Dist. Ann. Mag Nat. Hist. (6), x , p. 56, 1892.

Macrotristria extrema, Dist. Syn. Cat. Hom. Cicad., p. 32, 1906.

Hab—North Queensland, Northern Territory, North-West Australia.

Many specimens in Sydney and Melbourne Museums, and in Coll. H.A., and South Australian Museums.

MACROTRISTRIA DORSALIS, Ashton.

Macrotristria dorsalis, Asht. Mem. Nat. Mus. Melbne, (4), p. 30. Pl. iv., fig. a, 1, 2.

Types in National Museum, Melbourne. Co-types in Coll. H.A. *Hab.*—Queensland, Kuranda.

MACROTRISTRIA NIGROSIGNATA, Distant.

Macrotristria nigrosignata, Dist. Trans. Ent. Soc. Lond., p. 673, pl. xxix., fig. 7 a, b.

Specimen in South Australian Museum. *Hab.*—West Australia (Cossack).

MACROTRISTRIA FRENCHI, Ashton.

Macrotristria frenchi, Asht. Proc. Roy. Soc. Vic.
Type, female, in Coll. H.A. *Hab.*—Northern Territory.

MACROTRISTRIA HILLIERI, Distant.

Macrotristria hillieri, Dist. Ann. Mag. Nat. Hist., 1907, 7, xx., 413.
Macleay and Adelaide Museums, Coll. H.A, *Hab.*—South-Western Australia.

MACROTRISTRIA OCCIDENTALIS, Distant.

Macrotristria occidentalis, Dist. Ann. Mag. Nat. Hist., 1912, x, p. 438.
South Australian Museum and Coll. H.A.

MACROTRISTRIA VULPINA, Ashton.

Macrotristria vulpina, Asht. Proc. Roy. Soc. S.A.
Types in South Australian Museum, specimens in Coll. H.A. *Hab.*—West Australia.

MACROTRISTRIA MACULICOLLIS, Ashton.

Macrotristria maculicollis, Asht Proc. Roy. Soc. S.A.
Type, South Australian Museum. Co-types in Coll. H.A. *Hab*—North Queensland.

SYNOPSIS OF SPECIES.

A Venation of tegmina broadly infuscated toward apex.

M. angularis. Face and posterior pronotal margin castaneous. Thorax black, marked with yellow.

M. maculicollis Face and posterior pronotal margin black, latter spotted with yellow. Thorax black, marked with yellow.

M. thophoides. Face brownish, pronotal margins yellow. Thorax yellow marked with castaneous or black.

M. occidentalis. Face very prominent, piceous. Thorax castaneous or brown.

B. Venation of tegmina more or less spotted with fuscous.

M. doddi. Thorax brownish-ochraceous, much marked with black. Abdomen piceous.

M. nigronerosa. Thorax ochraceous, somewhat marked with black. Abdomen with yellow segmental margins.

M. hillieri. Thorax black and castaneous. Abdomen black front, very convex and prominent.

C. Wings not or every faintly marked with fuscous.

M. hieroglyphica. Thorax yellow, marked with castaneous. Abdomen castaneous.

M. godingi. Abdomen with yellow band toward apex.

M. sylvara. Body mostly green. Abdomen piceous, tegmina faintly marked with fuscous on anastomoses and apical longitudinal veins

M. extrema Thorax green or yellow. Abdomen black with segmental margins yellow, robust, tegmina unspotted.

M. intersecta. Thorax green, more marked with black than *M. extrema*, segmental abdominal margins yellow. Abdomen piceous to castaneous.

M. dorsalis. Thorax and abdomen yellow, black longitudinal dorsal patch on abdomen Tegmina immaculate

M. frenchi Body chestnut, head yellow, pronotal margins yellow.

M. nigrosignata *Body and head chestnut* Tegmina with basal cell black.

M. vulpina. Body piceous to castaneous. Allied to *M hillieri*, but smaller, and tegmina unspotted.

Genus **Cicada**, Stal.

Type *C plebeja*, Scop (Asia Minor)

CICADA GRAMINEA, Distant

Cicada graminea, Dist Ann Mag. Nat. Hist. 7, xiv, p. 428, 1904.

Cicada queenslandica, Kirk Canad Ent, 41, p 391, 1910

Female.—Head and thorax grass-green, pronotum inclining to ochraceous (probably through discolouration). Head with basal and lateral areas to face, transverse fascia between eyes, basal margin and area of ocelli, purplish-brown. Pronotum with two central lines (united anteriorly and posteriorly), and incisures purplish-brown Mesonotum with two short obconical spots, on each side a longer spot, central lanceolate spot. Spot in front of each anterior angle of cruciform, elevation purplish brown, outwardly margined with greenish ochraceous. Abdomen above somewhat thickly greyishly tomentose. Body beneath and legs more ochraceous than abdomen, the latter with some central discal

transverse spots and some smaller sublateral spots purplish-brown. Tegmina and wings hyaline; tegmina with costal membrane and venation of basal areas greenish, remaining venation fuscous. Venation of wings greenish. Head truncate in front, half as long as space between eyes, and (including eyes) as wide as base of mesonotum. Anterior femora armed below with two strong spines. Posterior tibiae with three spines, placed on each side on apical halves. Rostrum not quite reaching posterior coxae. Long, female, 76 mm., exp. teg., 85 mm. *Hab.*—Queensland.

Division Dundubiaria, Dist.

Genus Dioeropyga, Stål.

Type *D. obtecta,* Fabr.

Diceropyga obtecta, Fabr.

Tettigonia obtecta, Fabr. Syst. Rhyn, p. 35, 1863.
Cosmopsaltria obtecta, Dist. Mon. Orient. Cicad., p. 67, pl. v., fig. 13 a, b, 1890.
Diceropyga obtecta, Stal Ofv Vet Akad Forh, p. 708, 1870.
Dundubia bicaudata, Walk. List Hom. Suppl., p 6, 1858.
Dundubia subapicalis, Walk Journ Linn. Soc Zool, x., p. 87, 1867.

This species, the home of which is in Papua, was taken for the first time in Australia by Mr. J. A Kershaw, in January, 1914, on Lloyd Island, near the mouth of the Claudie River, North Queensland These specimens are now in the National Museum, Melbourne There are also specimens recorded from Queensland, in the South Australian Museum. I have a number from Papua.

Genera of Doubtful Habitat.

Cryptotympana, Stal.

Type, *C. pustulata,* Fabr (China).

Cryptotympana pustulata, Fabr.

Cicada pustulata, Fabr. Mant. Ins, ii, p 266, 1787.
Tettigonia atrata, Fabr. id. loc, p 267, 1787
Cicada atra, Sign. Rev. Mag. Zool., p. 406, 1849, pl. x, fig. 1.
Fidicina bubo, Walk List. Hom., i., p. 82, 1850.
Cryptotympana nigra, Stal. Hem. Fabr. ii., p. 6. 1869; God. and Frog., Proc. Linn. Soc., N.S.W., p. 592, 1904.

Cryptotympana pustulata, Dist. Mon. Orient. Cicad., p. 86, pl. xi., figs. 10 a, b, 1891.

That this species has been found in Australia is very doubtful. It is recorded by Goding and Froggatt on the authority of one specimen, determined by Walker in the National Museum, Melbourne.

Several specimens in Coll. H.A., from China.

Dundubia, Amyot and Serville.

Type *D. mannifera*, Linnaeus.

DUNDUBIA MANNIFERA, Linn.

This species is regarded by Distant (Syn. Cat. Hom. Cicad., 1906), as of Australian habitat. Moulton in his published "Material for a Fauna Borniensis," follows Distant. It may, of course, have been found here, but there are no specimens from Australia in any of the museum collections I have examined. I have, however, several specimens from Borneo and Java, and it is just conceivable that the range may include Australia.

Sub-family GAEANINAE, Dist.

This sub-family is distinguished by the partially cryptic tympana. The degree of concealment varies very considerably, the tympanal coverings being in some cases, as in *Tamasa,* almost obsolete, and in others, such as *Tettigia,* fairly well developed. South America is the home of the sub-family, practically all the larger species there belonging to the Gaeaninae. This sub-family, however, is very poorly represented in Australia.

Division CICADATRARIA, Distant.

Genus **Tettigia**, Amyot and Serville.

Type, *T. orni*, Linnaeus (Europe.)

TETTIGIA INTERRUPTA, Walk.

Cicada interrupta, Walk. List. Hom., i., p. 175, 1850.

Tettigia interrupta, Dist. Gen. Ins. Fasc., 158, p. 3, pl. i, fig. 1 a, b.

Hab.—New Holland, Walk. The habitat of this species is, I think, somewhat doubtful.

I have not seen anything quite typical of the specimen figured by Distant in the Genera Insectorum, but I have one specimen in my collecion—the only one I can refer to this species—from Western Australia. The colouration of this specimen is darker than the one figured, and the fuscous fascia across the bases of the apical areas of the tegmina only extend as far as the fourth.

TETTIGIA BURKEI, Distant.

Tibicen burkei, Dist Proc. Zool. Soc., 1882, p. 126, pl. vii., fig, 3 a, b.
Tettigia variegata, God. and Frog. Proc. Linn. Soc. N.S.W., 1904, p 594, pl. xviii., fig. 9, 9a.
Tettigia burkei, Dist. Syn. Cat. Hom. Cicad, 1906, p. 74.
Specimens in all Museums. *Hab.*—Queensland.

TETTIGIA HILLI, Ashton.

Tettigia hilli, Asht. Proc Roy Soc, S.A
Specimens in Macleay Museum (labelled by Goding and Froggatt *Tettigia tristigma*, Germ.), South Australian Museum, National Museum, Melbourne, and Coll H.A (types). *Hab.*—Northern Territory (Darwin)

SYNOPSIS OF SPECIES

T. interrupta Fuscous fascia extending unbrokenly along bases of apical areas.
T burkei. Fuscous spots to anastomoses and tips of apical veins.
T. hilli. First two anastomoses only infuscated

Genus **Tamasa**, Distant.

Type *T. tristigma*, Germar.

TAMASA TRISTIGMA, Germ.

Cicada tristigma, Germ. Silb. Rev. Ent., ii., p. 69.
Tibicen kurandae, God. and Frog. Proc. Linn. Soc., N.S.W., 1904, p. 603.
Tibicen doddi, God. and Frog. Proc. Linn. Soc. N.S.W., 1904, p. 602.
Tamasa tristigma, Dist. Syn. Cat. Hom. Cicad., 1906, p. 75; id. Gen. Ins. Rasc., 158, p. 4, pl. 1, fig. 3 a, b, 1914; Asht., Mem. Nat. Mus. Melb., pl. iv., fig. f 1, 2, 1912.

In all Museums. *Hab.*—Queensland, New South Wales.

I do not feel at all sure that *T. doddi*, God. and Frog., is not entitled to specific rank. This species is without the three distinct infuscations of the tegmina which give the name to Germar's species. Correlated with this feature is the considerably larger size. I have seen many large ranges of both these Cicadas. The two exist in the same localities, without any intermediate forms to link them. At all events, I certainly must regard *T. doddi* as a distinct variety.

Tamasa rainbowi, Ashton.

Tamasa rainbowi, Asht. Rec. Aust Mus. Sydney., ix., 1, 1912, p. 106, fig. 41 a, b.

Types, male and female in Australian Museum (Sydney). *Hab.*—Northern New South Wales.

Synopsis of Species.

T. tristigma. First two anastomoses and apex infuscated in tegmina.

T. rainbowi. All anastomoses and tips of longitudinal veins infuscated.

Genera of Doubtful Habitat

Goding and Froggatt include *Tympanoterpes hilaris*, Germ., *Huechys vidua*, and *Gaeana maculata*, Drury, amongst the Australian Cicadas I do not know their authority for the first, and the authority for *G. maculata* is one specimen out of three in the South Australian Museum, Adelaide, labelled :" Northern Territory." It may be Australian, but that evidence is not good enough. I have *T. (Proarua) hilaris* from S. America, and *G. maculata* from China. I certainly cannot consider them as Australian on the available evidence.

[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921]

Art. VII.—*Note on the "Dimpling" of Granite Hills in Sub-Arid Western Australia.*

By J. T. JUTSON.

(With Plate V., Figures 1, 2.)

[Read 12th August, 1920.]

In the south-central sub-arid portion of Western Australia, a large number of low and comparatively small isolated hills of granite rise above the surrounding elevated plain or plateau, which forms so marked a feature in Western Australian physiography. These hills are usually almost, if not entirely, destitute of vegetation and of soil, and they are like minute scattered islands rising from the sea of ordinary vegetation-bearing country. They have played an important part in the exploration and opening-up of the interior of Western Australia; for it is at their feet, or on their sides that "soaks" or rock holes, carrying water, may be found. It is on such supplies that the aborigines largely depended, and they were a most valuable aid to the white man in penetrating to the arid interior of the continent.

These hills show the usual rounded flowing surface—due to spheroidal weathering—common to granite in many parts of the world; and also the boulders that result from such weathering. They, however, differ from the moister areas in the peculiar undermining and hollowing out from below upwards of many of the boulders, the result of which processes is to be seen in the grotesque forms often assumed by the granite.

In addition to these features, several hills that the writer has seen—and doubtless what is to be described is a common phenomenon—show, when examined in detail, a peculiarly irregular, although still rounded, outline. This feature is due to the occurrence of a number of shallow cavities or holes, and the general effect is a dimpled appearance of the surface. Hence the term "dimpling" may be used to indicate the process by which such cavities are formed. The "dimples" are circular, elliptical or oval in outline, are from two to three feet to ten feet or more in their longer diameters, and are from a few inches to three or four feet deep at their deepest part. Their walls

may be approximately uniform in height, but frequently, opposite walls taper to a low lip over which surplus water may pass. The "dimples" may be scattered irregularly over the surface of the hill, or they may be collected along somewhat definite lines, such as a drainage furrow incised by erosion in the side of the hill, in which latter instance they form a series of hollowed-out steps; or both classes may occur. Rain water remains in these shallow holes usually but a short time.

The granite hills known to the writer on which the characters described may be observed, are the 19 Mile Rocks situated about 17 miles east-north-east of Goongarrie railway station[1], and at the Donkey Rocks, about 18 miles farther east-north-east; also to a less extent at the 22 Mile and 25 Mile Rocks, to the east of the 19 Mile Rocks.

With regard to the mode of formation of these "dimples," they are probably formed in much the same way as the more normal rock or "gnamma" holes, of which the "dimples" merely form a variety. The mode of formation of "gnamma" holes has been discussed by Maclaren, by Talbot and by Woodward. Maclaren[2] favours solution as the essential process, the narrow openings of some holes being due to a hard surface crust resisting erosion more than the rock below. Talbot[3] believes that they may have originated either by the decay of a rock with more felspar than the adjacent rock, or by a shallow crack in the granite. Solution by water charged with carbonic acid would enlarge the incipient hole, and animals and aborigines would still further enlarge them by scratching the sides, and removing the weathered rock to obtain the last drop of water. Woodward's ideas[4] are practically the same as Talbot's, except that he does not refer to the possibility of a crack or joint facilitating the commencement of a hole, although one of his figures shows the effect of a joint in the making of a hole. Woodward suggests that a beginning may be made by the more rapid weathering out by water of segregations in the form of pegmatitic bunches than of the containing rock. Animals then scratch out the remaining grit.

1. This railway station is on the Kalgoorlie-Leonora line, and is about 58 miles north of Kalgoorlie.
2. Maclaren, J. M.—Geol. Mag., 1912, pp. 301-304.
3. Talbot, H. W. B.—Bull. 45, Geol. Surv., W.A. (1912), pp. 38, 39.
4. Woodward, H. P.—Bull. 57, Geol. Surv. W.A. (1914), pp. 33-35.

The present writer does not at present desire to discuss the mode of origin further than to state that he agrees with the authors just mentioned as to the commencement of the hole being in some instances due to more easily eroded portions of the rock surface, than other portions, and also as to the effect of joints and of solution in the formation of various gnamma holes. With regard, however, to the "dimples" the subject of this paper, joints, so far as the writer has observed, have had little or no influence in the excavations. Solution on the other hand has undoubtedly played an important part. In the case of "dimples" formed along a drainage furrow on the side of a hill, the mechanical action of water, when the holes overflow after heavy rain, and the water passes from one hole to another by a series of low waterfalls, must, to some extent, be responsible for the erosion.

DESCRIPTION OF PLATE V., Figures 1, 2.

Fig. 1.—A series of "dimples" in an erosion furrow on a side of the granite hill. The furrow commences at the top towards the right hand side, and runs to the centre of the photograph. 19 Mile Rocks.

Fig. 2.—An individual "dimple" or rock hole on a side of the hill. A channel is being cut backwards towards the lip of the hole owing to the overflow at the lip. The hole is empty, but the height that the water reaches is clearly shown on the photograph. 19 Mile Rocks.

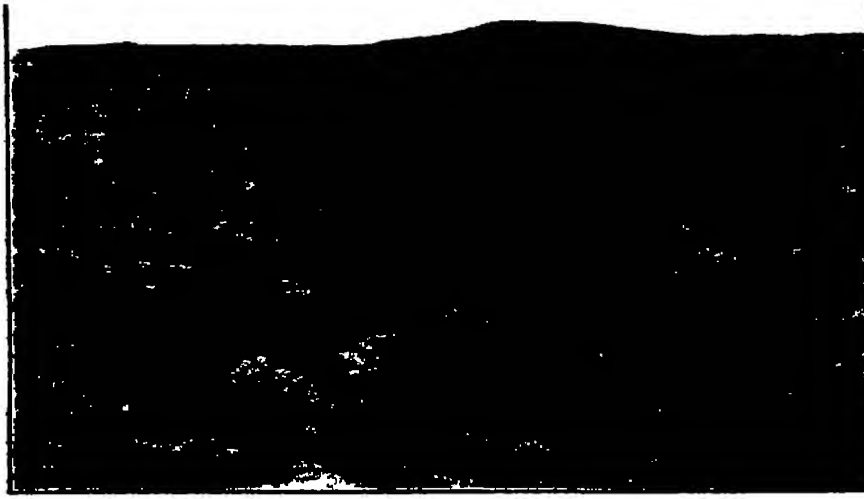

FIGURE 1

FIGURE 2

[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921.]

Art. VIII.—*An Example of Gravitational Drift of Rock Debris in Parallel Lines in Sub-Arid Western Australia.*

By J. T. JUTSON.

(With Plate V, Figure 3.)

[Read 12th August, 1920.]

Gravitational Drift of Rock Debris in General.

One of the most striking features of portions of the interior of sub-arid Western Australia is the widespread surface covering of fragments of the hardest rocks. These fragments may rest on bedrock, or, as in most cases, on the surface soils; and the action of rain and wind removes any fine material that lodges on or between such rock fragments, so that the stony character of the ground is maintained over wide areas. These rocky fragments are usually not more than three or four inches in size, and are frequently less than this. They form in places the "pebble armour of the desert," as described for other areas, by Hobbs[1] and by Mawson[2]. Such areas are also termed "stone fields."

This rock debris must often have travelled considerable distances, but the rocks that do so are only the hardest, such as quartz, dense ironstones and jaspers. Fragments of most other rocks, even those usually regarded as hard and weather-resisting, such as some fine-grained basic ones, are practically never found far from the parent rocks, showing that their disintegration must be comparatively rapid. This fact is of value in geological mapping.

As to the mode of travelling of the hard fragments, the direct transporting action of water seems, except along the beds of some watercourses, to be out of the question. The travelling rock debris, however, is not restricted to these watercourse beds, but is found in all positions, and, amongst others, on gentle slopes where nothing but gentle rills of water, without any de-

1. Hobbs, W. H.—"The Erosional and Degradational Processes of Deserts, with Especial Reference to the Origin of Desert Depressions." Annals Assoc Am. Geog., Vol. VII., p. 48.

2. Mawson, D.—"Geological Investigations in the Broken Hill Area." Mem. Roy. Soc., South Aust., Vol. II., 1912, p. 230.

fined channels, at times flow, and these are quite unable to move the rock debris[3].

Such debris seems to travel slowly along by mere gravitational drift, aided or brought about by the removal of the underlying soil by rain and wind, on account of which the fragments topple forward. The "clawing" action of rain, which the writer has already described[4], is a potent factor in this respect.

As a general rule there is no particular arrangement of the rock debris except in the case of the remarkable mosaics, or "desert pavements," and in the example to be now described of the drift of the rock debris in parallel lines.

Gravitational Drift of Rock Debris in Parallel Lines.

The example of this parallel drift occurs on the floor of Lake Goongarrie, a "dry" lake immediately to the east of the mining township of Goongarrie, which is 55 miles north of Kalgoorlie. The bed rock is a compact, almost black, shale, somewhat indurated, which breaks easily under the hammer in hand specimens, but which, when it forms a floor, as it does here, is quite firm. The shale is well laminated and strikes about N. 10° W.; it is practically vertical, but dips if anything to the west. At the precise locality referred to, it is quite free from debris, except for the quartz detritus to be presently described. In the shale is a quartz reef, with approximately the same strike and dip as the shale itself. This reef is a foot or more thick, and some yards in length. It projects from two to four feet above the shale. The reef is breaking down into fragments of various size, and these fragments drift over the shale away from the reef. This drifting material protects, to some extent, the shale from erosion, so that the ground rises into a low hillock, culminating in the quartz reef, a few feet above the surrounding ground. It is on the eastern side of this reef that the example referred to occurs, and the greatest inclination (which however, is only a few degrees) of the ground on this side of the reef is to the east, and at right angles to the strike of the shales. Water falling on the hillock on the eastern side of the reef therefore flows *across* and *not with* the strike of the shales.

3. See Jutson, J. T.—"Sheet-flows, or Sheet-floods, and their associated phenomena in the Niagara District of sub-arid south-central Western Australia," Am. Journ. Science, Vol. XLVIII (1919), pp. 435-439.

4. Proc. Roy. Soc. Vict., Vol. XXXII (N.S.), Part I. (1919), pp. 20-21.

On this eastern side of the hillock, the white quartz debris (which is in fragments of all sizes up to six or more inches in length) is arranged in parallel lines, which are in turn parallel to the strike of the rocks, with spaces between the various lines, free or largely free, from the quartz debris. These interspaces, therefore, are the colour of the underlying shales, which here are almost black. There are thus more or less alternate dark-coloured and white bands parallel to one another and to the strike of the rocks, represented by the shales and by the quartz debris respectively The width of the bands varies from about three to six inches. The dark-coloured areas are not entirely free from quartz, nor are the quartz bands quite continuous, but distinct parallel bands do exist as described above

As regards the mode of formation of these parallel bands, the direct action of rain must be excluded No fall would be sufficient to remove the larger fragments of quartz. Moreover the inclination of the ground, and consequently the flow of water when rain falls, are across and not with the parallel bands, and hence the rain could not form the furrows described below. It may also be noted that immediately after rain, the banding is much less distinct, in consequence of fine sand being washed out from the quartz bands on to the shale bands. The only possible explanation of the banding that occurs to the writer is that the wind is mainly responsible Fine sand is available from the quartz decay, and from adjacent areas The shales are eroded differentially by ordinary disintegration and weathering along their line of strike in their exposed parts, that is, where the quartz rubble is scarcest The wind sweeps this disintegrated portion away as well as probably rasping the surface with the fine sand available. This tends to create a furrow running at right angles to the slope of the ground. In addition, the quartz rubble becomes undermined by removal of the underlying shales by the same action, with the result that the quartz fragments topple forward—no doubt gradually—and fall into the furrow. The "ridge" lately occupied by the quartz debris then similarly becomes furrowed, and the band of quartz debris behind, then occupies such furrow. Thus there is a slow gravitative drift of the quartz debris in parallel lines, and at the same time the shale surface is gradually being lowered as a whole. The furrows formed in this way are somewhat akin to the "yardangs" of arid North America and elsewhere.

The suggested explanation has objections to it. A number of loose stones of various sizes and shapes would apparently move forward, even under the special conditions of furrowing postulated, at very different times, and thus the parallelism of the lines would be destroyed; and before it was regained, practically the whole of the stones on the "ridge" would have to fall into the furrow. This could possibly, and perhaps does, as suggested above, occur, since the stones remaining on the ridge would continue to be undermined, whilst those reaching the furrow would escape this process for the time being Such a peculiar combination of conditions may occasionally result, but it could hardly be expected to be widespread, and apparently it is not. The matter is brought forward so that further instances in Western Australia or elsewhere might be searched for and studied in the field. So far as the writer is aware, no other example of gravitational drift of rock debris in parallel lines has been recorded.

Tolman[5] has emphasized the importance of a "desert pavement" as a protection of the underlying rocks against erosion. Such pavements of quartz occur at Goongarrie, and will be described in another paper. The present paper, however, shows that where the pavement is not complete, although there is a measure of protection, yet considerable erosion may take place. It may be remarked in this connection that S Goczel[6] had as early as 1894 pointed out that the pebble-covered areas were a protection against wind erosion of the underlying material.

DESCRIPTION OF PLATE V. Figure 3

Fig. 3.—The white quartz debris is derived from the reef in the background. Bands of black shales are shown alternating with parallel bands of quartz debris, especially in the foreground. The bands are parallel to the strike of the shales.
Floor of Lake Goongarrie.

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5. Tolman C F—"Erosion and Deposition in the Southern Arizona Bolson Region" Journ Geol., 1909, Vol. XVII, p. 149.

6. Göczel, S.—"Report on the Central Goldfields of Western Australia," Appendix V., pp. 24-33. Ad Interim Report of the Department of Mines for half-year ending 30th June, 1894.

[Proc. Roy. Soc. Victoria 33 (N.S.), 1921.]

Art. IX.—*Possibilities of Modifying Climate by Human Agency, with Special Application to South-Eastern Australia.*

By E. T. QUAYLE, B.A.
(Supervising Meteorologist, Commonwealth Meteorological Service).

[Read 9th September, 1920.]

Many attempts have been made by more or less violent means to compel the atmosphere over dry areas to part with its moisture, and all have been futile. In the following paper, evidence is brought to show that methods more in accord with Nature's requirements are actually successful.

The proofs, or evidences, are mainly dependent upon the rainfall data controlled by the Commonwealth Meteorological Service, and deal only with the Southern parts of Australia.

The most important climatic conditions in any one latitude are in general dependent upon the distribution of land and water areas. As this is mainly so on account of the difference in evaporation from them, we may substitute for water areas the term "evaporation areas." It is possible to conceive of sufficient evaporation for abundant rains from areas remote from the ocean, though, of course, under the planetary condition of atmospheric circulation, it may be impossible to make any inland district absolutely self-contained as regards its water vapour. Evaporation results have shown that a land surface, if well grassed, may give rise to greater evaporation than a water surface. This is also probably true of forest coverings in the ordinarily moist climatic regions, though not, I think, of forests in countries subject to prolonged droughts, times of very low humidity, and high temperatures, such as is the case in inland Australia. Our forest vegetation has to become specially adapted to meet drought contingencies. Taking, for example, the forest covering of our Mallee districts, consisting mainly of various species of dwarf Eucalypts, one cannot fail to be struck by its unmoved appearance after the worst of droughts, even the 18 months' drought of 1913-14-15, and the serious summer drought of 1911-12, leaving the trees as fresh looking as ever. Of course, there was probably not the usual amount of growth, but the trees had not lost much of their vitality.

Quite apart from the results of experiment in measuring plant transpiration, it would thus appear obvious that these trees

possess remarkable control over their rate of transpiration, such that at the first hint of drought pressure, they declare a state of siege by closing their stomata. Assuming that they do this during the first warmth of spring they will contribute little towards the humidity of the atmósphere during the periods of east to north winds and falling barometers preceding the approaching "lows." They are too much on the defensive to aid in rain production

This is, however, not the case with growing crops, such as wheat, oats, etc., which obviously wilt in the hot winds, or with most of the grasses. As one of the main objects of cultivation in the dry areas is to store moisture in the soil for the use of the growing cereal crops, it is almost essential for successful cropping that the land should lie fallow for twelve months, and be occasionally worked to prevent weed growths dissipating the water content of the subsoil, and, as this is drawn upon most in the spring months, the plants must then transpire freely. They, therefore, contribute generously to the atmospheric humidity, and so aid in producing conditions favourable for rain. This reasoning suggested a test. If this is correct, stations in the older Mallee areas, or those in the south-eastern edge of the cultivation area, which is gradually increasing by encroachment upon the Mallee in a north-westerly direction, might be expected to show some slight improvement in their spring conditions as compared with old stations beyond which no great advance has yet been made. This might be shown by rainfall or temperature, or by both.

To test the matter, the following groups of stations were chosen:—Tyrrell Downs, Swan Hill, and Kerang to represent the remoter and least benefited portion; Charlton, Lake Marmal and Wychitella South, the area which might be the gainer from the substitution to north-westward of cereal crops and grass for Mallee scrub. The area separating the two groups is about 55 miles across Kerang was assumed to be too far north to benefit, but both that station and Swan Hill are south-east from areas being rapidly developed by irrigation, and should be in a different category in the years to come. All of these stations have rainfall records as far back as 1885, and this was chosen as the starting point. Comparisons were made of the mean rainfalls for the three following decades, 1885-94, 1895-1904, 1905-1914. The results were quite favourable to the theory. Two groups of spring months were chosen—September and October, and

August to November, though the last might possibly have been better with November out of it, as in some years the grass is dry, and the crops nearly ripe long before the month is ended. The rainfalls for these periods were expressed as percentages of the annual amount, and these are shown in the following tables:—

(a) STATIONS TOO FAR NORTH OR NORTH-WEST TO BENEFIT BY SPREAD OF CULTIVATION.

Period	Swan Hill Percentage of Annual Rainfall		Kerang Percentage of Annual Rainfall.		Tyrell Downs. Percentage of Annual Rainfall	
	Sept.-Oct.	Aug.-Nov.	Sept.-Oct.	Aug. Nov.	Sept. Oct.	Aug.-Nov.
1885-1894 -	18·1	38·4	18·4	35·7	18·6	39·3
1895-1904 -	17·7	32·7	17·9	36·0	15·8	35·0
1905-1914 -	16·1	31·5	15·7	30·4	17·4	32·3

(b) STATIONS BENEFITTING, IF AT ALL, BY SPREAD OF CULTIVATION.

Period.	Lake Marmal *Percentage of Annual Rainfall*		Wychitella S *Percentage of Annual Rainfall*		Charlton *Percentage of Annual Rainfall*	
	Sept.-Oct.	Aug.-Nov.	Sept. Oct.	Aug. Nov.	Sept. Oct.	Aug. Nov.
1885-1894 -	18·4	38·5	16·76	36·25	17·7	36·5
1895-1904 -	19·5	36·5	17·8	31·5	19·16	34·5
1905-1914 -	19·05	35·1	18·5	33·9	17·96	33·5

In the first group the September-October rains declined by 2.0, 2.7, and 1.2 per cent., giving a mean decrease of 2 per cent. In the second group there were increases of 0.65, 1.84 and 0.26 per cent., giving a mean rise of 0.9 per cent., or a relative gain for that period of about 3 per cent. of the annual total, or about *half an inch of rain.* For the four months' period for (a) we get decreases of 6.9, 5.3 and 7.0 per cent., giving a mean of 6.4 per cent. For (b) the declines were 3.4, 2.3 and 3.0 per cent., giving a mean of 2.9 per cent., or a relative gain of 3.5 per cent., thus suggesting that the benefit is not quite limited to the two months, September and October.

The assumption with regard to this selection is, of course, that in (a) we get simply the effects of periodic seasonal variation, and with (b) we get the periodic variation plus that due to the change of environment. If the deduction is correct, we have quite a marked improvement in spring conditions at Lake Marmal, Wychitella South, and Charlton, owing, we will say, to the evaporation from wheat and grass lands lying to north and west of them.

It might be said that any gain in the spring rainfall would be at the expense of the rains of other parts of the year. It is not

probable I think As regards the three winter months—May, June and July—the smallness of the latitudinal temperature gradient aided by the more rapid cooling of continental areas, enables even the most ordinary type of Antarctic disturbance to bring rain as far inland as the Murray River and in summer thunderstorm tendencies over the Mallee will be greater with the alternation of ploughed fields and narrow timber belt than they would be with the uniformity of Mallee scrub and its tendency to cool the lower levels of the atmosphere The experience of aviators tends to confirm this last

That the gain in this case was not confined to the spring months is evident by the following tables showing the mean annual totals —

	1885 94	1895 04	1905 14
Swan Hill	15 15	11 20	12 28
Tyrrell Downs	15 91	10 36	11 45
Kerang	16 76	11 71	14 13
Means	15 94	11 09	12 62

	1885 94	1895-04	1905 14
Charlton	18 59	14 01	16 55
Marmal	17 16	12 16	14 06
Wychitella	16 56	12 66	16 23
Means	17 44	12 94	14 95

Calling the first 1885 94 group mean A and the second 1885 94 group mean B the other means may be expressed as per centages of these as follows —

A 69 A and 79 A and B 74 B and 86 B

These show relative gains of B over A of 5 per cent and 7 per cent or actual annual gains of about 0 9 and 1 2 inches

It may be added that in the selection of stations no attempt was made to pick and choose The first selection was the one used Kerang is not however quite as well situated as the others for the purposes of this investigation but it was the only other Victorian outpost station with long enough record The results from two others might have been given Waitchie about mid way between Tyrrell Downs and Swan Hill only goes back to 1893 but well supports the former and Murray Downs which is on the New South Wales side of the Murray supports Swan Hill

Substituting these for Kerang we get the following results, which quite support the spring difference between the two rainfall groups, and indicate an even greater annual difference The

mean annual rainfall for the three successive decades for Swan Hill, Tyrrell Downs, Waitchie, and Murray Downs, are 15.6 in., 10.9 in., and 11.9 in., giving A, .69 A, and .76 A.

Creation of Water Surfaces.

It is perhaps not possible to store water in such amounts inland, as to distinctly increase the general humidity of the atmosphere, but "every little helps." It is possible that the rainfall averages along the shores of some of our land piercing inlets may be indicative of future possibilities. There are two very suitable for examination—Spencer's Gulf and Port Phillip Bay, and it fortunately happens that the shores of both are fairly well lined with rainfall stations.

The length of Spencer's Gulf is great compared with even its greatest width, hence winds bearing rains from the open ocean are confined to a small angle, and this is so nearly due south that but little rain could be brought in from that direction. Except near the entrance, where elevated land just inland from stations on the western shores of the Gulf gives these an increased rainfall, the western stations have a distinctly lower rainfall than the eastern ones This difference appears to be about 2½ inches 50 miles from the entrance, where the Gulf has a width of about 70 miles, and slowly increases to 3 inches as far north at Pt. Broughton, where the distance from the entrance is about 130 miles, and the width 32 miles. Thence it diminishes to zero at the head of Port Augusta

If Spencer's Gulf were silted up, it would be incredible that the rainfall on the resulting low level plain, especially in its northern portion, should be superior to that of, say, Yardea or Nonning, which stand on plateux of about 1000 feet in elevation to westward. As the average rainfalls of these stations are only about 10 inches, the rainfall near the head of the Gulf should almost certainly be less, say, about 8 inches. This would make the narrow strip of water forming the northern part of the Gulf responsible for an increase of 3 to 4 inches on the western shore, and 5 or 6 inches on the eastern.

For the sake of more definiteness as to the effect of evaporation from the waters at the head of the Gulf in increasing the rainfall, I have analysed the rainfalls at four of the stations with regard to the chief wind directions. The stations are Port Pirie and Hummock's Hill, Pt. Lowly and Germein. These form opposing pairs. Between Pt. Pirie and Hummock's Hill the

Gulf is about 19 miles wide, though, owing to coastal irregularities, the two places are about 28 miles apart. Point Lowly and Point Germein are 12 or 13 miles apart on opposite sides of the base of a narrow triangular water area, the apex of which is 45 miles further north Owing to the way Pt. Lowly projects into the Gulf, it is only about 30 miles from Pt. Pirie, in a north-westerly direction. All four stations are practically at sea level. The wind directions were determined from the 9 a.m. weather charts, and it was, therefore, necessary to deal with the total wind change in 24 hours, which, of course, varied considerably. These total variations were grouped as follows: Winds veering (a) from north through west to south by west, (b) from north through west to west-south-west, (c) from between west-south-west and south by west, (d) winds with an easterly component (e) indeterminate, as in purely cyclonic circulations. Seven years' daily records were used, and the results for each year (1911-1917) are shown in the following table:—

Year	N through W to S by W				N through W to W S W				W S W to S by W			
	Port Pirie	Hummock's Hill	Port Germein	Point Lowly	Port Pirie	Hummock's Hill	Port Germein	Point Lowly	Port Pirie	Hummock's Hill	Port Germein	Point Lowly.
1911	159	114	162	65	157	25	87	56	293	157	324	177
1912	59	68	37	24	262	142	196	136	204	151	203	205
1913	94	67	63	13	254	94	229	158	188	29	124	31
1914	37	10	14	18	68	57	70	78	32	4	10	11
1915	7	—	6	—	302	238	340	228	221	89	210	159
1916	196	99	106	72	516	235	414	361	475	179	304	252
1917	108	40	72	63	582	360	432	374	165	48	98	72
Sums	660	407	400	285	2231	1160	1798	1391	1588	657	1423	907
Means	94	58	69	41	319	167	257	199	227	94	203	130

Year	Easterlies				Intermediate				Annual Totals			
	Port Pirie	Hummock's Hill	Port Germein	Point Lowly	Port Pirie	Hummock's Hill	Port Germein	Point Lowly	Port Pirie	Hummock's Hill	Port Germein	Point Lowly
1911	388	334	330	446	206	643	289	237	1275	1273	1201	1006
1912	366	533	421	405	346	331	208	218	1294	1224	1217	992
1913	265	465	242	300	262	278	214	258	1011	945	875	790
1914	479	777	415	552	213	131	167	179	886	986	695	839
1915	129	223	170	200	599	407	452	576	1348	958	1180	1183
1916	420	588	405	517	331	360	264	300	1950	1461	1598	1506
1917	391	582	361	472	717	552	612	650	1942	1600	1592	1632
Sums	2447	3502	2353	2892	2734	2702	2266	2418	9656	8447	8360	7948
Means	350	500	336	413	391	386	324	345	1379	1207	1194	1135

The results are very interesting. Comparing Port Pirie and Hummock's Hill we see that as regards winds from the western half-circle, half the total rain at Port Pirie comes with winds from between N. and W.S.W., and for these the average gain per annum over Hummock's Hill is 1¼ inches, the rainfall being apparently increased by that amount and almost doubled by moisture taken up from a 20-mile stretch of water. The same proportion holds for the westerlies in general, which give 318 points to Hummock's Hill, and 640 to Port Pirie.

Now, taking the winds with easterly components, the gain to Hummock's Hill over Port Pirie is nearly as substantial, the Port Pirie rainfall of 3¼ inches under easterly winds being raised to 5 inches from the moisture picked up in the passage over the water. This is perhaps even more than one would have expected as in some instances the rain clouds would be moving in a different direction from the surface winds, and would carry back to Port Pirie some of the added moisture.

Similar results are to be obtained from other comparisons. For example, taking Point Lowly and Port Germein; for winds between N. and W.S W—these not traversing the greater areas of the Gulf—the relative gain to Port Germein is 0 58 inch, and for easterlies, the relative gain to Pt. Lowly is 0.77, which is quite as much as one would expect considering the nearness of the two stations, and the way Pt. Lowly projects into the Gulf, enabling it to gain not only from easterly winds, but at times from northerly or even west-south-westerly winds.

It would thus appear that out of the ten inches of Port Pirie's rainfall under definite wind direction, at least 3¼ inches come from the adjacent waters, and if the same proportion holds for the indeterminate portion, the total gain will be at least 4½ inches. Hence, if the Gulf were silted up, its annual rainfall would not exceed 9 inches, and would probably be less, thus bearing out the previous more generally derived opinion.

The rainfall data from Port Phillip Bay are equally striking, stations on the Eastern shores receiving up to ten inches more than Western stations in the same latitude.

It is hardly necessary to remark that it is in rainy weather the principal additions to the rainfall must be made by local evaporation. Under generally anticyclonic conditions, as in some of our great drought years, the rains must largely fail; but the value of the increased amount in more favourable years is not thereby lessened.

In this latter respect Southern Australia enjoys a position different from that of some almost rainless countries, such as Egypt, where, in spite of irrigation on a grand scale, no marked increase of rainfall is observed. When the upper air has a humidity consistently much below that necessary for rainfall, the provision of any limited evaporation area is not likely to bring it up to the point of rain production, but in Southern Australia the upper air is sufficiently humid for a little rain with the passage of almost every Antarctic disturbance. This may help to explain the marked assistance which this paper suggests evaporation areas to have towards rainfall production. In the very dry central portion of the continent it might be much more difficult to trace such effects.

(2) By Irrigation.

In the south-eastern portion of the continent fairly extensive schemes have been brought to partial fruition, the chief of which are the fruit-growing areas at Mildura, Merbein, Renmark (in South Australia), and Curlwaa (in New South Wales), all near the extreme north-west corner of Victoria, and probably giving some 30,000 acres of fully irrigated lands. Then, upstream, along the Murray, are areas irrigated for lucerne and fruit at or near Swan Hill, Cohuna, Koondrook, etc., aggregating in 1912-13 some 90,000 acres. From the Goulburn some 60,000 acres more were irrigated in the same year. As most of this area would be rather dry in average years—certainly the 120,000 acres directly irrigated from the Murray and Loddon would be—there must be considerable evaporation from these, which would not be available under purely natural conditions To these are being added considerable areas in Victoria, and the comparatively large Murrumbidgee irrigation areas in New South Wales supplied from the Burrinjuck reservoir.

These schemes have all been undertaken without reckoning upon any climatological improvement as the result. But it is probable that even from that point of view, we shall have interest for our money, and not simple, but compound, interest. If the rainfalls on the eastern and western shores of Spencer's Gulf and Port Phillip Bay are any guide, a 20 mile expanse of water may increase the rainfall by several inches, and, as the evaporation from irrigated areas is at least equal to that from ocean surfaces, and the irrigated areas are already large enough, stations

to south-east and south from these should show some benefit from them, at all events during the chief growing season.

In dealing with the effects of sheets of water upon our own climate I have already shown the benefits derived by parts of South Australia from the Spencer Gulf, even as far north as Port Augusta, and especially around Germein Bay, from a sheet of water twenty miles across. Not many of our storages would compare in area even with this body of water, but it has to be remembered that the surface of the reservoir is multiplied many times by any effective scheme of irrigation. For example, the Burrinjuck reservoir has an area of only 20 square miles, but will hold at any one moment water enough to irrigate to a depth of one foot 771,000 acres, or 1200 square miles If such an area as that could be irrigated, the evaporation resulting would be such as to have a most important effect not only upon the rainfall of the adjacent areas, but upon the precipitation over the area feeding the reservoir itself

So far, only some 40,000 acres are occupied for the purpose for which this storage was made, but in Victoria in 1916 a total of 288,000 acres were under irrigated culture. When the 1,000,000 acre foot storages on the Upper Murray and the Sugar Loaf scheme on the Goulburn are added to the Burrinjuck, and the various other storages completed or projected, the area can be vastly increased.

Data from stations bordering on or within the irrigation areas give some indications of rainfall effects, but these are necessarily indefinite. The uncertainties as to the distribution of the areas under irrigation, the crops irrigated, whether of grass, wheat, lucerne, etc, and the variation in effect owing to differences in the character of the seasons, etc, make only very approximate estimates possible. Before 1891, when the Goulburn Weir was constructed the area of land irrigated must have been infinitesimal, and up till 1895, owing to abundant rains, there was little need for irrigation. The county of Rodney was the most favourably situated to make use of the Goulburn supplies, but this was not completely reticulated till 1904, by which time the Waranga basin was under construction. In 1904-5 the total area irrigated was 166,000 acres. Of this Rodney had 40,000, Tragowel 29,000; Cohuna 29,000, Macorna 11,000, Swan Hill 10,000, Wardilla 9000, etc. This rapid development was owing to the series of drought years which culminated in 1902. By 1906-7 the area was less, rose to 232,000 in 1907-8, another drought year,

and fell to 130,000 in 1909-10, a very good season. Then, on to 1914, the increase was marked, and in 1913-4 reached 317,000 acres. Since then, or to April, 1918, there seems to have been little or no progress, the rainfall having been very abundant.

In attempting to show some possible effects of this upon the rainfall, one must assume that we have some groups of stations in the neighbourhood affected, and some unaffected by the evaporation from these areas. For the latter, I chose Echuca, Numurkah and Yarrawonga, which are all north or north-east from the principal area, though Echuca may now be affected by the Murray irrigation lower down. For the former we have Sheppparton, Tatura, Murchison, most favourably situated to benefit as they are south-east from the Rodney irrigation area. Kyabram is too well within the area to benefit fully, and Rochester and Elmore are south-west of it. As a check group we may take Violet Town, Euroa and Benalla, which are further to south-east, probably too far to benefit appreciably, but useful to throw light upon variations in rainfall distribution during the decades Another group is Rushworth, Whroo, Nagambie and Seymour From Waranga Reservoir the first is 2½ miles south-west, the second 6 miles south-south-west, Nagambie 15, and Seymour 33 miles south of it. These also, it may be assumed, would not be so likely to benefit as the winds reaching them from the Rodney irrigation areas would require a slight easterly component, and the other areas are rather remote. The results may be shown as follows, expressing the means for each station for the successive decades, 1885-94, 1895-1904, 1905-1914, in terms of the first as unit.

Stations assumed Unaffected.			
Echuca	1·00	72	78
Numurkah	1·00	65	74
Yarrawonga	1·00	·72	·76
Mean	1·00	·70	76

Stations assumed Affected			
Shepparton	1·00	·84	·01
	1·00	·75	·80
Murchison	1·00	·77	·81
Tatura	1·00	·77	·83
Mean	1·00	·76	·81
or	1·00	·78	·84
Kyabram	1·00	71	·80

Check Groups.

South-Eastern.			
Benalla	1·00	79	·75
Euroa	1·00	·75	·79
Violet Town	1·00	·75	·77
Mean	1·00	·76	·77

Southern			
Rushworth	1·00	·66	·73
Whroo	1·00	·71	·75
Nagambie	1·00	·72	·76
Seymour	1·00	·77	·78
Mean	1·00	·715	·755

It is difficult to get any series of rain records in which we can place absolute confidence. The records for Shepparton prior to 1897 are based upon those from Crumlin Vineyard, which should have been sufficient, as that station is only 1¼ miles away from Shepparton, but concurrent records 1897-1904 gave a difference between them of nearly 15 per cent. of the Crumlin Vineyard record. That may have been real only for these latter years, as a 14 years' series from Mooroopna supports Crumlin Vineyard from 1891-94. However, the two are shown, the upper line giving full weight to the Crumlin Vineyard 1885-96 record, and the second treating it as needing a plus correction of 15 per cent. The truth probably lies between the two. Patched records may also account for the discrepancy between Rushworth and Seymour. The figures, however, give strong support to the assumption that stations south-east from the main irrigation area benefited by an increase of at least 5 per cent of the annual rainfall, or of fully one inch. The last two groups tend to show that this apparent increase was not due to a difference in the rain distribution with regard to area and storm type in the successive decades.

Irrigation Increases the Means of Irrigation.

On the principle of "to him that hath shall be given, and he shall have abundance," it is more than probable that irrigation on any proper scale in Northern Victoria will increase the river supply available for conservation and irrigation.

Our mountain ranges are not high, but they are admirably placed to take advantage of improved evaporation results from the great inland area through which their waters flow They form almost a semicircle, running south through New South Wales, and then west through Victoria. As the moistened air must almost invariably move off eastwards, it must pass over this range, which reaches its greatest average elevation in the bend where it lies most directly in the path of the eastward moving air. This additional evaporation will not only increase over the mountain slopes every rainfall coming by way of the interior, but as mists are almost a constant feature of the mountain weather, the wetting effect of these will be greatly increased, often out of all proportion to the increased humidity. It may, in fact, be in this way that the improved conditions would be most manifest. Taking, for example, the average condition of temperature and humidity at Echuca, and assuming the eastward

moving air compelled to rise at least 3000 feet to cross the Australian Alps, it can be shown that up till nearly the end of October, every addition to the water vapour means so much extra condensation on the mountains

The monthly mean 9 a.m. relative humidities at Echuca from March to October are 55, 63, 78, 86, 85, 78, 70 and 55 per cent. (A minimum of 43 per cent. is reached in January). The corresponding 9 a.m. mean temperatures are 67°, 59°, 51°, 46°, 40°, 49°, 54°, and 62°, which are also very nearly the daily mean temperatures.

Now, since wind directions north of the Divide during these months are very largely from points in the northern semicircle, and almost entirely so in rainy weather, the air from the plains is eventually driven over the mountains froming "the Divide." This involves ascent of at least 2000 feet, and with westerly components of wind direction from 3000 to 4000 feet, owing to the altitude of that portion known as the Australian Alps. The ascent being forced, the rate of cooling up to condensation level will be adiabatic. The figures for March give the ascent necessary for condensation as 3060 feet, for April 2340 feet, May 1200 feet, June 720 feet, July 720 feet, August 1190 feet, September 1730 feet, October 3000 feet. Hence, we can say that during the winter half of the year, at all events, practically every addition to the moisture in the air over the plains, shows as cloud before crossing the highlands. The consequent lowering of the level at which condensation takes place would certainly, in all weathers, increase the effectiveness of fogs in wetting mountain vegetation, and in rainy weather would increase the rainfall probably to an extent greater than the actual addition. That the former is not negligible is well shown by Dr. Marloth's experiments on the moisture collecting power of vegetation in saturated air on Table Mountain.

Other Evidences of Increased Rainfall from Local Evaporation Areas.

(1) From River Floods.

Hints of evaporation effects increasing rainfall may be obtained from a study of the average annual rainfall maps of Northern Victoria and the Riverina, which show a marked tendency for the isohyets to form loops or peaks extending down the Murray and its numerous anabranches.

(2) Rainfall Increasing Eastwards without any Apparent Cause.

The whole rainfall distribution of the Riverina and Northern Victoria suggests that the watering of large areas of country downstream from Echuca and Deniliquin has some influence in causing increased rainfall as we go eastward, since the rainfall increases without any corresponding increase in altitude. It may be as suggested by me in an article written in 1910, on the "Rainfall Distribution over Victoria," that these eastern areas derive some benefit from their being more in the way of "monsoonal" disturbances than stations further west, but this should be balanced to some extent by the greater accessibility of the western stations to oceanic influences coming by way of the Bight At all events the differences are most remarkable. To quote from this article: "Benalla, with an altitude of 560 feet receives 26½ inches, while Wedderburn, 8 feet higher, gets only 18 inches; the altitudes of Balmattum and Sutherland are the same—565 feet—yet the former receives 25 inches, and the latter only 15½. Wangaratta, 493 feet, receives 24.8 inches and Lubeck, 488 feet, only 17.4 inches, and so on It may be remarked, too, that the western stations are in somewhat higher latitudes, which should help them.

This phenomenon may perhaps be explained somewhat as follows: If we follow the 36th parallel from near the mouth of the Murray inland, we notice a gradual decline of the rainfall which, by the time we reach Tyrrell Creek, has dropped by more than one-third, or from 21 inches to less than 13. This is evidently due, at least in part, to the failure of local evaporating surfaces to compensate for the rain since leaving the Bight. A change now, however, begins to take place; atmospheric humidity must be increasing, for without help from land altitudes the rainfall is increasing, giving recovery at Echuca by 4 inches, and at Yarrawonga by 7, or to that near the coast line. As the increase is coincident with entry upon country always undergoing natural, and in recent years artificial, irrigation, it is reasonable to assume some connection. The unimproved Mallee areas with their uniformity of green drought-resistant scrub growth probably evaporate evenly but miserly, and, as the country is flat, this evaporation does not disturb the plane-like cloud formation usual in front of oncoming storm systems, which may be one

cause of the small rainfall. But when cleared and large blocks of growing wheat or of green grass alternate with heat absorbing areas of fallowed land, we have a totally different effect. The uniformity of cloud stratification is broken by columns of heated air supplied with moisture from the green vegetation, and these tend to set up various convection centres which, when reaching the cloud level, draw upon the moist air of the cloud stratum, and cause local showers over areas which might otherwise be passed over. Thunder showers should also be of more frequent occurrence.

The same effect must, of course, result from irrigation, but with the advantage of not being limited to any season. It is quite probable, too, that these disturbances to the cloud layers rising from beneath cause local precipitation out of all proportion to the amount of moisture contributed by the evaporation areas.

(3) Persistent Increase of Monthly Rainfall during 1919 (a year of record irrigation) in Lee of Irrigation Area.

The monthly rain maps for 1919 seemed to indicate in a very striking way increased rainfalls due to irrigation, water conservation, and possibly previous flooding. The monthly isohyets showed a most persistent tendency towards increased rainfall beginning somewhere in the neighbourhood of Wentworth and Mildura, but most marked about Swan Hill and Kerang. Now, as both districts are the scenes of considerable irrigation development, and the latter of large water storages as well, a chain of lakes being kept filled for irrigation and water supply northwest from Kerang, we have an apparent cause of increased rainfall. The annual rain map for 1919 showed a strip of well-rained-on country from Euston to Mitiamo generally following the Murray, but diverging a little to southwards after passing Swan Hill. The year's rainfalls of Kerang and Mitiamo were actually above average, although the year was in general so dry that both N.E. and S.W. of this strip the rainfalls declined to 20, and even 30, per cent. below average. That this was no mere chance effect may be assumed from the fact that the monthly isohyets showed the same tendency in at least seven cases. The effect was possibly helped by heavy thunderstorm rains from Swan Hill to Kerang in February.

(4) Modification of Drought through Murray Floods.

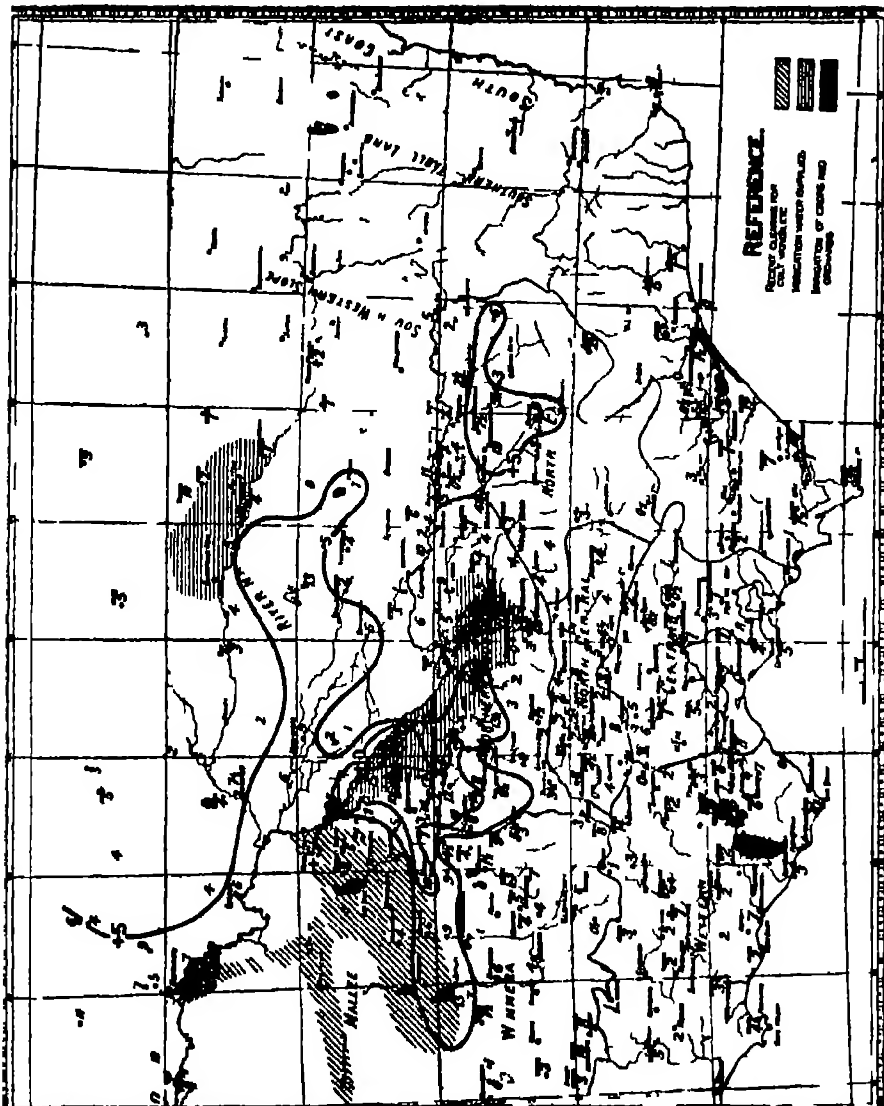
To see whether there was any evidence of the Murray floods causing subsequent rainfall improvement, I selected Murray Downs, an old and, I believe, very reliable rain station near the Murray on the opposite side from Swan Hill. This station has for 20 or 30 miles north-west from it a good deal of country apparently either marshy or well supplied with lakes, filled when the Murray is in high flood. As it is probably from this direction, or from west-north-west that the storms come in dry years instead of, say, from north-north-west, as in wet years, Murray Downs should, in dry years following flood, feel some effect. Having graphed the flood levels at Torrumbarry, I selected all the dry years immediately following one of heavy flooding in its latter half. There were 22 of these, beginning with 1868. Taking annual rain totals only, and comparing with those of stations presumably less favourably placed, Murray Downs should, in these years, receive a better percentage of the average fall than should, say, Wentworth, beyond which the river trends westerly, or Moulamein and Balranald, which are on the north side of the frequently flooded areas, or Tyrrell Downs, which is to southward of them. Using the records available, comparison with Wentworth shows 14 out of 18 years favouring Murray Downs, with Moulamein 8 out of 10, with Balranald 11 out of 15, and with Tyrrell Downs 8 out of 11 in favour of Murray Downs. These necessarily give much weight to the Murray Downs records, but these are well supported by those of Swan Hill. This peculiarity of Murray Downs is not as fully felt at stations further south-east, Kaarimba being less favoured than Murray Downs in only 17 cases out of 26, Numurkah 12 out of 16, and Yarrawonga 9 out of 15. It is, of course, probable that these stations also gain from the evaporation from the Murray valley. I may say that monthly comparisons do not show any marked increased frequency of benefit at Murray Downs over these south-eastern stations, although it does with the others. This was unexpected, but may point to the principal way in which the rainfall is increased, namely, by the production of convectional centres in ordinary rain storms, or by intensifying thunderstorm action, in which case the total annual benefit at any one station might be due to a few exceptional showers.

(5) Improved Rainfall of last Ten Years only marked in connection with Irrigation Districts and Mallee Improvements.

The foregoing considerations suggested another test. The decade (1910-9) being one of considerable progress in clearing and cropping of the Mallee, and especially in irrigation and water storage in the Kerang-Swan Hill areas, the districts immediately in lee of these should show some improvement in their annual rainfall. To show this it was obviously necessary to base all rainfall comparisons upon a common period. The best seemed to be the 30-year period, beginning with 1885. This, for Victoria, gave me a little more than 200 stations, for each of which I compared the average annual rainfall of the last ten years with that for the standard 30-year period. The percentage departures from this normal were plotted on a map The results were very striking. For almost all south of the Divide, the whole of the Wimmera, except the river drainages, and for the two Mallee stations east of Lake Tyrrell, the last ten years were slightly drier than the normal, and the same was the case with a few scattered stations in the Central North. Over the north-east and northern slopes generally there was an appreciable rise, averaging about 4 per cent. But there was one area showing a very marked rise From Swan Hill, along the Murray to Cohuna, the plus departures ranged from 12 to 15 per cent , and thence southwards to Korong Vale they exceeded 10 per cent. The area showing these increases exceeds 2000 square miles But this is not all. It is continued westwards in a narrow strip hugging the southern fringe of the newer Mallee clearings as far apparently as Lake Hindmarsh. The increase over this area approximates to 10 per cent. The larger increase may be assumed due to the combined effect of irrigation and Mallee improvements—the smaller to the latter only. It would, therefore, appear that the complete development of Mallee occupation will bring in a rainfall approximating to that of the lower Goulburn valley, and that irrigation will further increase this result.

On the accompanying map, kindly drawn by Mr. Curtin, the data just referred to are plotted. The numbers indicate percentage departures of the mean of the last ten years' rainfall (1910-1919), from that of the 30-year period, 1885-1914. The areas where the plus departures exceed 5 or 10 per cent. are

enclosed by curving lines, which might be termed the rainfall isopleths for the latter period



Summary.

To sum up, it may be said that there is sufficient ground for believing that the south-eastern States are all under such weather conditions that they will benefit climatically by any considerable

increases in surface moisture. The clearing of the land, and the substitution of cultivation or pastures for the scrub forests on the inland plains cause, according to the evidence, some improvement of the rainfall, especially during the spring months, when the green growth results in vigorous evaporation. A more general improvement results from irrigation, which ensures growth of vegetation throughout the year. It is through this means that the greatest effects are possible. The extension of irrigation along the Murray between Echuca and Renmark, and in New South Wales, about the junction of the Darling with the Murray, it is evident, will have a not inconsiderable effect in ameliorating the climate of Northern Victoria, including the Mallee It should also increase the rainfall on the mountains from which the irrigation water are derived. And if in connection with these, large storages of water are made from the lower Murray and Darling, say, by impounding flood waters in banked-up lakes in the same way as those of the Goulburn are impounded in the Waranga basin, the possibilities, if not almost limitless, are at least very great. I see no reason why the improvement should not be equal to what would happen if an arm of the sea like Spencer's Gulf, say, up to Menindie. It has already been shown that a reasonable result of this would be an increased rainfall of from 3 to 5 inches in the neighbourhood, even as far as 170 miles inland.

If such a result could be brought about by increasing our irrigated areas, and the necessary increase in the area of land fully irrigated can surely be made, it would be hard to put any limit upon the climatic benefits which Northern Victoria and the Riverina would derive from it. Hann has shown that in New South Wales a square mile of country carries 22 more sheep per annum with a 12-inch than with an 11-inch rainfall, and that the carrying capacity increases at a more rapid rate per inch of rain as the rainfall increases, a 17-inch rainfall, for example, enabling 70 more sheep per square mile to be carried than a 16-inch one.

Such an increase in our irrigated areas is likely, therefore, not only to be worth while in its direct effects upon the country's production, but by making further irrigation possible, to have indirect effects of very appreciable magnitude.

[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921]

Art. X.—*A Revision of the Genus Pultenaea, Part II.*

By H. B. WILLIAMSON.

(With Plates VI. and VII.)

[Read 9th September, 1920.]

Pultenaea humilis, Benth.

(Hook, f. Fl., Tasm., i., 91).

A shrub with flowers like those of *P. plumosa,* from which species it differs in having bracteoles with broad stipules, and flowers axillary in short leafy spikes at or near the ends of the branches, not in terminal heads. The common Victorian form is low and diffuse, with large flowers, the calyx lobes being much longer than the tube, lower ones much narrower than the upper, all hirsute with long hairs. Bracteoles are linear-lanceolate, ciliate, as long as the calyx lobes, and fixed at the base of the tube. The ovary is glabrous, with a brush of long white hairs at the top, and the style is much dilated Grampians, Geelong, Ballarat, etc., Vic.

It appears to be confined to the southern half of Victoria

P. humilis, var. glabrescens, var. nova.

Variat foliis fere glabris, floribus paulo minoribus saepe glabris.

From the normal this differs in having almost glabrous leaves, and somewhat smaller flowers often quite glabrous Specimens from Grampians and Creswick, with narrow leaves have fallen wrongly under var *angustifolia* of *P. parviflora,* Sieber, p. 132, Fl., Aust. The Grampians specimens are scantily invested with long hairs on the calyx and bracteoles, while those from Creswick have hairs only on the branchlets and pedicels. Goulburn River specimens (W. F. Gates), have larger, glabrous leaves and hairy branchlets and pedicels. Those from Sale, Vic., (T. A. Robinson), and Bairnsdale (T. S. Hart), have shorter leaves, broader towards the summit, and smaller flowers. All the specimens

agree with *P. humilis* in having the long thickened reddish style and glabrous ovary with tuft of hairs.

Benalla, N. E Sale, E. Victoria. Creswick and Grampians, Victoria.

P. SUBSPICATA, Benth.

(Fl., Aust., ii., 137).

A small shrub with the appearance of *P. vestita*, and the narrow leaved form of *P. humilis,* having leaves up to half-inch, narrow-lanceolate, concave, granular-rough, and slightly hairy. The calyx has narrow subulate lobes, rather longer than the tube. It is easily distinguished from *P. humilis* by its broad bracteoles with a central point fixed under the calyx tube; and from *P. plumosa* by its flowers being axillary, not in terminal heads.

L. George, and Braidwood dist., N. S W. There is a specimen collected in Gippsland, Vict., by Howitt.

P. VILLIFERA, Sieb.

(D.C. Prod ii, 111).

This species has been confused with *P. humilis,* and so has been wrongly recorded for Victoria In *P. villifera* the calyx is not more than 3 lines long, usually 2 lines, and the bracteoles are scarious, ovate-lanceolate, while in *P. humilis,* the calyx is 4 to 5 lines long, with a very short tube, and the bracteoles are very narrow, and as long as the calyx lobes.

The leaves of *P. villifera* are prominently veined beneath, with marginal veins also, and have longer petioles, especially the upper ones

Port Lincoln, Encounter Bay, Onkaparinga, S.A. Jervis Bay, N.S W.

P. INVOLUCRATA, Benth

(Fl. Aust. ii., 138)

This may be confounded with *P. villifera* which it resembles in general aspect, but it may be easily separated by its singly terminal flowers, and remarkably small calyx, scarcely more than 1 line, which is quite concealed by the broad bracteoles. The leaves are scarcely petiolate, and have no marginal vein.

Mt. Lofty, S.A.

P. MUELLERI, Benth.

(Fl. Aust. ii., 138).

This species is close to the last named, having solitary terminal flowers, and a small calyx, 2½ lines, almost concealed by the broad bracteoles; but it is not a villous plant, and the petioles are very short. Leaves are prominently 3-veined below, and are almost pungent.

Baw Baws, and S. Gippsland, Skipton, Vic. Specimens from Skipton have setaceous stipules and bracts.

P. PROSTRATA, Benth.

(Hook, f. Fl. Tasm. i., 89).

This resembles *P. Muelleri* in its singly terminal flowers, but it has linear, terete leaves resembling those of *P. laxiflora* and *P. tenuifolia.*

Its nearest affinity is *P. tenuifolia,* from which it is easily distinguished by its constantly single flowers with silky calyx, and numerous closely imbricated bracts.

Wimmera dist. Portland Vic. Ross, Tas. Tattiara, S A.

P SETULOSA, Benth

(Fl. Aust. ii., 132).

Small shrub with linear, terete or trigonous leaves, channelled above, mucronate, 3 to 4 lines long, scarcely spreading. Stipules are rather broad, appressed, reddish, with long fine points.

Flowers are axillary, nearly sessile, crowded near the ends of the branches. Bracts none. Bracteoles linear, on the base of the calyx tube, provided with stipules. Calyx pubescent, lobes about as long as the tube, fine pointed. The fine points to stipules, leaves and calyx-lobes give it a peculiar aspect.

Broad Sound, Q.

Specimens from Mt. Lindsay, Q. (Cambage, 1909), have calyx rather smaller and stipules less setular.

P. VESTITA, R Br.

(Benth. Fl. Aust., ii., 132).

Small shrub with young branches quite covered with long closely imbricate reddish stipules, each pair united almost to the top. Leaves linear, or linear-lanceolate, shortly mucronate.

Flowers in dense leafy terminal heads. Floral leaves and bracts with large, broad stipules. Bracteoles under the calyx, large, stipular, scarious with pointed lobes, and central long-ciliate point.

In calyx and bracteoles it resembles *P. elliptica,* and *P. subspicata,* but differs from the former in having much narrower leaves, smaller petals, and longer bracteoles; and from *P. subspicata* in having much longer bracteoles, and flowers terminal.

Sherratt's Brook, Esperance Bay, W.A. Port Lincoln, Salt's Creek, S.A.

P. STROBILIFERA, Meiss.

(Pl. Preiss., i., 75).

A shrub to 1½ feet with terete wrinkled leaves about 3 lines long, and flowers in dense ovoid heads, with numerous broad, shortly-toothed bracts covering the calyx. Bracteoles are linear, hirsute, with long hairs, and are fixed under the calyx, which has long, narrow and acuminate lobes

The style is short, thick and hooked.

Stirling Ra., Upper Hay R., Sources of Blackwood R., W.A.

P. ERICIFOLIA, Benth.

(Lindl., Swan Riv. App., 13).

A shrub, heath-like in aspect, much resembling *P. strobilifera* in calyx lobes, bracteoles and style, but its leaves are longer, and its bracts are spreading at the top, deeply trifid, with subulate central and broad lateral lobes. The long setular calyx lobes and bracteoles are fringed with long hairs, giving the heads a fuzzy appearance.

King George's Sound, Swan R., Blackwood R., W.A.

P. VERRUCULOSA, Turcz

(Bull. Mosc., i., 278).

A species resembling the last two, but having fewer bracts, and broader bracteoles, all much shorter than the calyx. The leaves are glabrous.

King George's Sound. Great Bight, W.A.

Var. *pilosa,* Bth., sprinkled with long hairs, and with bracts rather larger and more numerous, and petals dark red.

Cheyne's Beach, Oldfield, W.A.

Var. *brachyphylla,* Bth., leaves short and thick, sometimes shortly mucronate, and flower heads smaller.

P. RADIATA, sp. nova.

Fruticulus erectus parvus, ramulis, radiatis pubescentibus, foliis lineari-cylindricis supra canaliculatis tuberculatis incurvatis 8-10mm. longis patenti-hispidis, stipulis subulatis, floribus sessilibus in capitula terminalia confertis, bracteis paucis lato-ovatis ciliolatis, bracteolis bracteis similibus calycem omnino cingentibus eoque fere aequilongis infra basin calycis insertis, calyce glabro margine ciliato 7 mm. longo, lobis acuminatis inferioribus tubum aequantibus superioribus conjunctis usque supra medium, vexillo bis longiore quam calyx, ovario sericeo-villoso apice barbato stylo brevi (vix 3mm. longo) uncinato; legumine non viso.

This plant resembles *P. ericifolia* and *P. verruculosa*, var. *pilosa*, in general aspect.

1.—*P. ericifolia* has very distinctive flowers, having very long bracts with a long central ciliate lobe, and linear bracteoles as long as the calyx lobes, both the latter being ciliate with long hairs.

2.—*P. verruculosa* has bracts few, short, entire, or shortly two lobed, and bracteoles only about 2 lines long, and linear, hairy, trigonous leaves.

3.—This species has very broad bracts and bracteoles, the latter completely surrounding the calyx, longer than the tube, and the upper calyx lobes are much connected, with their lobes scarcely divergent The hooked style is shorter than that of *P. verruculosa*, var. pilosa, being scarcely more than a line in length, with the hairs of the ovary reaching almost to the top.

Its nearest affinity appears to be *P. Bauerleni*, F.v.M., a N.S.W. species which has a calyx of the same size and shape, and bracteoles also large, but somewhat narrower, larger and broader stipules, longer, thicker, mucronate, long-petiolate leaves, granular without hairs, and a silky ovary tapering to a long subulate style. The ovary of this species is silky, with long hairs reaching almost to the top of the very short hooked style.

In National Herbarium, Vic., from Busselton, W.A, 1870 A. and E. Pries, among specimens of *P. verruculosa*, var. *pilosa*.

P. ADUNCA, Turcz.

(Bull. Mosc., i., 79).

A species with terete leaves scarcely ½ inch long, with often a small recurved point. The calyx is uniformly silky and has the

lower lobes narrower and longer than the tube, the upper ones being broad and united almost to a single emarginate lobe.

Bracteoles are linear, silky, and fixed below the calyx, and the style is short, thick and hooked.

" Drummond's 5th Coll. n. 66," W.A..

Apparently rarely gathered.

P. NEUROCALYX, Turcz.

(Bull, Mosc., i., 281).

A W.A. shrub somewhat like *P. subumbellata* in foliage, habit and absence of stipules, but at once known by its bracteoles and calyx lobes, which are striate with scarious ciliate margins. The bracteoles are under the calyx, ovate-oblong, three nerved. Calyx lobes are almost equal, broad, blunt, and 3 to 5 nerved. The style is short, thick, and hooked. The plant appears to be one of the connecting links between *Pultenaea* and *Phyllota*. Examination of ripe seeds may show that it should be placed under the latter genus.

Oldfield, Mt. Barren, Robertson's Brook, W A.

P. JUNIPERINA, Labitt.

(Pl. Nov. Holl., i., 102).

A plant with pungent leaves varying much in width, and flowers two or three together towards the ends of the branches, with lanceolate bracteoles inserted under the calyx Specimens from Tasmania and the Grampians have narrow spreading leaves, concave or conduplicate, with a wide base, and pedicels about a line long with a prominence at the base

Var. LATIFOLIA, Benth. (*P. cordata*, Graham), a form with broad leaves almost cordate at the base, tapering to a pungent point, darker green below with a prominent midrib

R. Tamar, Tas.

P. JUNIPERINA, var. PLANIFOLIA, var. nova.

Variat foliis longiorbus latioribusque planis vel paululum concavis.'

This form has leaves from ½ inch to 1 inch long, lanceolate-oblong to oblong, from slightly incurved at the margin to quite

flat, partly rusty-red below, the prominent midrib below being prolonged into a straight pungent point. Flowers are usually in twos at the ends of very short branchlets, appearing almost axillary.

This is the plant mentioned by Bentham, p 135, "Clarence River, Beckler," as var. *mucronata* of *P. flexilis,* but it differs from *P. flexilis* in having bracteoles inserted under the calyx, not upon it, and having a villous ovary and subulate stipules. Beckler's specimens exactly match those from Gibbo Ra. Vic., determined by Mueller as *P. juniperina.* Specimens from Pine Mt., N.E. Victoria (C French, jnr.), having flat leaves up to 1 inch long must be referred to *P. juniperina* for the reasons just stated.

Dandenong Ra., N.E. Victoria, and N.S.W.

P. RIGIDA, R.Br.

(Benth., Fl. Aust. ii., 130).

A species very close to *P. juniperina.* Bentham gives for it, "Leaves lanceolate, concave or conduplicate, flowers distinctly pedicellate," but the Grampians specimens of *P. juniperina* also possess these characters.

If we admit the validity of the species, we must do so on the following grounds Leaves conduplicate, very rigid, sessile, flowers dark red, on rather longer pedicels, and pod ovoid, not oblique-ovate, shorter than that of *P juniperina.* I have not seen the pod, or the Memory Cove specimens.

The leaves show sometimes a tendency to reticulate venation as in *P. aciphylla,* and they have not the distinct yellowish petioles with the protuberance at the base

Memory Cove, (R Brown); Kangaroo I., (O Tepper), S.A

P. ACEROSA, R.Br.

(Benth., Fl. Aust., ii., 131).

A species with terete or trigonous leaves, channelled above, rigid, pungent short-pointed, slightly recurved, divaricate on the lower branches, and nearly ½ inch long. Flowers are dark coloured, crowded, surrounded by bifid, subulate bracts, and have oblong bracteoles with subulate points.

Coast of S. Australia.

Var. ACICULARIS, var. nova.

Variat foliis strictis longe mucronatis, floribus minus confertis, petalis minus rubris.

From Mt. Lofty, S.A. Has been placed by Bentham under *P. acerosa.* Mueller's MS. name for it was *P. acicularis.* It differs from *P. acerosa* in habit and in colour of flowers, which contain less red, and the leaves have long straight points.

The flowers are much less crowded, often appearing in twos as in *P. juniperina,* and having bracteoles and calyx closely resembling those of that species.

It appears to be a connecting link between *P. acerosa* and *P. juniperina.*

P. COSTATA, sp. nova.

Frutex diffusus circiter 1m. altus, ramulis pilosis, foliis, ovato-lanceolatis 7-9mm. longis rigidis recurvatis glabris concavis pungenti-mucronatis subter prominenter supra levius quinquenerviis inflorescentiam versus confertis, stipulis longe subulatis patentibus, floribus sessilibus in capitula terminalia confertis, bracteis multis lato-ovatis acuminatis, bracteolis bracteis, similibus lato-ovatis subulatis infra calycem affixis, calyce 8-9mm. longo sparse villoso lobis subaequilongis subulatis, vexillo vix longiore quam lobi calycis, ovario sericeo-villoso, stylo sublato; legumine non viso.

Specimens of this plant occur in herbaria variously placed under *P. styphelioides*[1] and *P. juniperina,* var. *latifolia* (*P. cordata,* Graham). Only by a casual inspection could it be placed under the former. From the latter it differs considerably, as it has crowded sessile flowers, with a large calyx almost concealed by bracts. As these and the calyx are long-subulate, the inflorescence has a bristly appearance The leaves are prominently 5-veined while in *juniperina* they are 1-veined.

Its nearest affinity is *P. acerosa* which it resembles in inflorescence, calyx and bracts, but from which its remarkable 5-veined leaves keep it distinct.

Grampians, N. of Mt. William, Vic. C. French, jnr., C. Walter, J. W. Audas and others.

P. LAXIFLORA, Benth.

(Fl. Aust., ii., 133).

A shrub with narrow-linear leaves, often with a blunt recurved tip, minutely pubescent when young. Flowers are in terminal

heads, at first surrounded with broad bracts which soon drop off, and then the pedicels appear often 2 to 3 lines long and turn downwards. Bracteoles are linear-lanceolate, fixed on the calyx tube, are provided with broad stipular lobes, and are inclined to be leafy. The calyx and pedicels are silky pubescent.

Grampians, Wimmera, Vic.

Var. PROCUMBENS, F.v.M.

A MS. name, under which Mueller placed the S A. specimens Leaves broad, almost flat in some specimens, cuneate, recurved at the end in others.

Lighter green above with a distinct midrib below. Some specimens show less pubescence, and more slender calyx lobes and bracteoles.

Onkaparinga, Clarendon, S.A.

Var. PILOSA, var. nova.

Variat floribus confertioribus, pedunculis brevioribus, calyce valde vestito.

Specimens from "N.W. of Nhill," Vic., (D'Alton) are in an early stage, and show bracts rather larger than the normal. The calyx and bracteoles are invested with long silky hairs.

To this variety also must be referred specimens from Mt. McIvor, (Mueller), and Bendigo, (Paton), which have been passing under *P. tenuifolia.*

Their flowers in terminal heads, their large calyx, and leafy stipular bracteoles separate them from that species.

From the normal they differ in having flowers often more crowded on short branchlets. The pedicels do not appear to lengthen much, and the calyx is somewhat larger, and is invested with long hairs.

Northern part of Victoria.

P. VILLOSA, Willd. (Spec. Pl., ii., 507).

Under this name a number of very divergent forms have been included, which can scarcely be admitted even as varieties.

I have taken Sieber's specimens, "n. 421," and "Fl. Mixt. 518," as typical, agreeing with Bentham's description. Shrub pubescent, or villous, rust coloured when dry. Leaves usually oblong, or somewhat cuneate, concave, or with incurved margins,

tubercular or hirsute underneath. Flowers solitary in each axil, but sometimes forming short terminal leafy racemes. Pedicels short and slender. Bracteoles inserted on the calyx tube near its base, linear, with often one or two setae in their axil. Calyx 1½ to above 2 lines long, lobes acuminate, longer than the tube, the two upper ones broad, falcate, united to the middle, lower ones narrow. Smith, in Trans., Linn., Soc. 9, 248, says, " A dense bushy shrub, with numerous short leafy branches, and copious, axillary solitary flowers. The appendages (bracteoles) grow from towards the base of the calyx, and are longer than the tubular part, having a more leafy appearance than in any other species of *Pultenaea.*"

Hobart, Tasmania; Port Jackson district to South Queensland. The Victorian forms will be dealt with later.

P. FERRUGINEA, Rudge.

(Trans. Linn. Soc. xi., 300, t 23; D.C Prod. ii., 111)

Bentham, p. 134, included this under *P. villosa* as var. *latifolia.* The leaves are obovate and vary from 2 to 3 lines in Blue Mountain specimens, to 4-5 lines in specimens from the seaboard. This character, together with its large long appressed stipules like those of *P. elliptica*, its large flowers and peculiar bracteoles, separate it well from *P. villosa.* The calyx is very large, often 5 lines long, its upper lobes being falcate, joined below the middle, and the lower ones are very narrow, much longer than the tube. Bracteoles are lanceolate, almost as long as the calyx lobes, fixed at the base of the tube, and provided with broad scarious stipules, both calyx and bracteoles being invested with long soft hairs. Flowers are axillary, crowded in terminal and sub-terminal leafy racemes. The ovary is glabrous except for a tuft of long white hairs on the summit. The style is long and distinctly compressed.

Blue Mts., Port Jackson, Guise Head, etc., N.S.W., " n. 420 Sieber," in Nat. Herb., Melb.

P. FERRUGINEA, Rudge, var. DEANEI.

(P. Deanei, R. T. Baker, Proc. Linn. Soc., N.S.W., xxii., 438, 1897.)

This plant is simply a large form of *P. ferruginea*, having rather larger leaves, up to 6 lines long, scarcely as hairy as the

normal plant. With the broadening of the leaves the obscure marginal veins of *P. ferruginea* become more distinct, and further from the margin, giving the leaves a tri-nerved character. The leaves are obovate-cuneate, not inclining to oblong as shown in the plate accompanying the description, and the bracteoles are fixed at the base of the calyx tube, not high adnate as the plate shows.

It is a much more robust and showy plant than the normal *P. ferruginea,* and grows, according to Mr. H Deane, only on the sandstone of the Hawkesbury series Intermediates occur, however, at Guise Head. (R. Brown), Berowa and other places.

Peats' Ferry (H Deane); Gosford (R. T Baker).

P HISPIDULA, RBr

(Benth., Fl Aust, ii, 133)

In habit resembling *P villosa,* but with much smaller flowers which are sessile in small terminal heads, instead of being axillary and solitary The bracteoles also are quite different, oval-oblong. The calyx is scarcely more than a line long, with very short lobes, and the ovary is villous, instead of being hairy only at the top. Port Jackson, N S W

Specimens from Gembrook, Grampians and other parts of Victoria, hitherto passing under *P. villosa* must be referred to this species.

P PARVIFLORA, Sieber.

(D.C Prod ii., 111)

This is a form very near to *P. villosa,* differing only in its almost sessile flowers, which are rather crowded in the upper axils, and its smaller leaves almost glabrous.

The leaves are more cuneate than those of *P. villosa,* and in the South Creek specimens, N S.W. (J H. Maiden), are slightly notched at the summit. Calyx, bracteoles, and ovary as in *P. villosa.*

The form which it most closely approaches is Rudge's *P. polygalifolia,* which Bentham rightly included under *P. villosa,* and from which I can separate it only by the size and shape of its leaves. It may yet have to be reduced to a var. of *P. villosa.*

C. Byron, Port Jackson, South Ck. N.S.W.; Ipswich, Q.

It does not occur in Victoria.

P. GRAVEOLENS, Tate.

(Trans. Roy. Soc., S.A., vii., p. 68.)

A species with small oblong to linear leaves, and axillary flowers. Mueller evidently placed it as a form of P. villosa, but it can be separated from that species by its smaller calyx, peculiar hyaline and viscid stipules, and bracteoles, and its peculiar odour, which is described by Tate as like that of "spirit contaminated with animal matter." To some it has a rich aromatic odour, some times resembling that of cream cheese. It comes between *P. villosa* and *P. hispidula*, and is distinguished from the latter in having axillary flowers, and very small bracteoles.

Uraidla, Mt Lofty, S.A.; Meredith, Vic., (S Johnson).

P. VROLANDI, Maiden.

(Vic. Nat. Vol. 22, p. 98.)

Resembling in general aspect some forms of *P. villosa*, but easily distinguished by its cup-shaped, involucre-like, viscid bracteoles, fixed under and quite surrounding the calyx, which has short and broad lobes. In the Nat Herb, Melb., are specimens of this plant from Pine Mt, N.E Vic. (C Walter, 1891), the leaves of which are 5 lines long

Strathbogie, Vic., Nov 1904 (A. W. Vroland).

P. TRIFIDA, J. M. Black

(Proc Roy Soc., S.A., xxxiii., 224, 1909.)

A S.A. species with small, concave, ovate, petiolate leaves, ending in a short bristle point. The calyx is small with almost equal lobes. It has a general resemblance to *P. ferruginea*, but the flowers are very different, having lobes of the calyx almost equal and subulate, and its trifid bracteoles serve to easily distinguish it from all its co-geners.

The bracteoles are distinctly trifid, the outer lobes not being acceptable as stipules, as in the case of *P. plumosa*, *P. ferruginea*, and *P. laxiflora*.

Snug Cove, and Cape Borda (Griffiths, 1908). Cygnet R., (1886, O. Tepper, Vic. Nat. Herb.).

P. WEINDORFERI, Reader.

(Vic. Nat., Vol. 22., p 51.)

A showy species resembling a form of *Dillwynnia ericifolia*, which may account for its being overlooked, although growing abundantly so near to Melbourne. It has linear concave leaves, crowded, and scarcely spreading, and long, appressed stipules. The calyx resembles that of *P. humilis*, var. *glabrescens*, its nearest affinity, in being most glabrous, and in having calyx lobes longer than the tube, and linear bracteoles fixed near the base of the tube, but it differs from that species in having more equal calyx lobes, and a quite glabrous ovary and style.

Wandin, Vic., 1903 (G Weindorfer). In the Nat. Herb. from Dandenong Range, with no date or collector's name.

P. VISCIDULA, Tate.

(Proc. Roy. Soc., S.A., vii., p. 69.)

A shrub about 3 ft. high, resembling *P. mollis* in foliage, but less hairy, and having flowers in small, not in dense, heads, with very small bracts and bracteoles. The latter are ovate, and are fixed under the calyx tube.

The growing ends of the branchlets are "clothed with a viscid exudation." Tate.

Under shade of *Eucalyptus corynocalyx*, Karatta, Stunsail, Boom R., S A., Kangaroo I., (Tate).

P. FASCICULATA, Benth.

(Benth. Fl., Aust. ii., p. 139.)

A prostrate or diffuse alpine shrub with foliage like that of *P. tenuifolia*, slightly silvery in appearance. Flowers are axillary and solitary, with a single broad-lobed bract. Bracteoles are lanceolate-acuminate, and are set on the calyx tube. The calyx is silky pubescent, with acuminate lobes as long as the tube, the upper ones broader.

Highlands of N.S.W., Tas, and Vic. 2000-5000 ft.

P. CAMBAGEI, Maiden and Betche.

(Proc. Linn. Soc, N.S.W., xxx, 308.)

=*P. subumbellata*, Hk *var. cambagei*.

A shrub differing from *P. subumbellata* only in leaves and habit. The leaves are somewhat narrower, and show little differ-

ence of colour below. The description in the Fl. Aust. of *P. subumbellata,* "shrub either low and erect, or taller and straggling, with branches virgate, rather slender, terete, pubescent when young," includes M. & B.'s description of this plant, so that the species seems to have been founded on the difference in leaves only, a rather unwise proceeding, especially as some specimens of *P. subumbellata* show leaves with both pages equally green.

Torrington, New England, N.S.W. (Cambage, 1907.)

P. tenuifolia, RBr.

(Bot. Mag., t. 2086, Benth Fl. Aust. ii., p. 139.)

A small diffuse shrub with villous branchlets, and leaves narrow-linear, or terete, 2 to 4 lines long, concave or channelled above, generally straight and pointed, almost fascicular, and invested with minute appressed hairs.

Flowers are sessile, solitary, or two together at the ends of the branchlets, and are surrounded by broad bifid scarious bracts, concealing the calyx Bracteoles are ovate, and are fixed under the calyx, longer than the tube. The calyx is about two lines long, with almost equal lobes, acuminate, and slightly longer than the tube. In Port Lincoln specimens the lobes are invested with long white hairs

S. coast of Vic., S.A., and W Australia

Var. *Glabra,* Benth, almost glabrous. Wimmera Dist., Vic.

P. recurvifolia, sp. nova.

Frutex erectus parvus, ramis pubescentibus, foliis 3-4 mm. longis angustis recurvatis apicem versus latioribus margine involutis, supra vix apertis infra leviter carinatis, glabris vel minutissime puberulis, stipulis acuminatis latiusculis, floribus paucis minimis prope apicem ramulorum axillaribus, bracteis nullis, bracteolis ovatis calyce brevioribus infra cum affixis, calyce 2 mm. longo glabro, lobis brevibus latisque minute ciliolatis superioribus paululum latioribus, vexillo 5 mm. longo fusco, alis pallentibus, ovario sericeo-villoso, stylo subulato, legumine, 3 mm. longo, 2 mm. lato.

This plant was included by Bentham under *P. tenuifolia,* RBr., as var. *recurvifolia.*

Its small recurved leaves, axillary flowers, and the absence of bracts separate it well from that species. Its flowers also

are much smaller, and the calyx lobes shorter than the tube. The bracteoles, however, resemble those of *P. tenuifolia.*

Its nearest affinity appears to be *P. villosa* from which it differs in its narrow, recurved, leaves, and different shaped calyx, which is more like that of *P. hispidula,* which, however, has flowers terminal in small clusters.

Cape Nelson, near Portland, Vic. (Allitt.)

P. ECHINULA, Sieber.

(D.C., Prod. ii., 112; Benth., Fl. Aust. ii., 127.)

Shrub with older branches denuded of leaves, and tuberculate or echinate with the remains of their petioles. Leaves 6-7 lines long, crowded on the younger branches, much incurved, linear, terete, channelled above, tuberculate, and, towards the inflorescence, invested with scattered long hairs. Stipules long-subulate. Flowers in dense heads surrounded by crowded leaves, with few bifid bracts with spreading subulate lobes.

Bracteoles inserted under the calyx, short, broad at the base, tapering to a sharp point, minutely ciliate Calyx glabrous, minutely ciliate, lobes nearly equal, acuminate. Keel dark coloured. Ovary glabrous, with a few long hairs at the summit.

The National Herbarium contains a single specimen of the type referred to in Benth., Fl. Aust., p. 127. "Sieb n. 384. New Holland." It does not appear to have been gathered since.

P. DIVARICATA, sp. nova.

Frutex erectus fere glaber, foliis lineari-cylindricis confertis supra canaliculatis tuberculatis mucronatis divaricatis incurvatis strictis vel deflexis floralibus puberulis, stipulis subulatis, floribus circiter 6 sessilibus in capitula terminalia congregatis, bracteis breviter bifidis pubescentibus, bracteolis linearibus carinatis dorso paululum pubescentibus 2 mm. longis ad basin calycis affixis, calyce 4 mm. longo pubescente, lobis obtusis inferioribus tubo aequilongis superioribus eo paulo brevioribus, petalis omnibus flavis, ovario sericeo-villoso, stylo subulato, legumine oblique ovato 5 mm. longo, 4mm. lato, planiusculo pilis longis parce vestito.

This plant, from the Blue Mts., N.S.W., which has passed as *P. echinula,* Sieber, appears to be the plant mentioned by Bentham —Fl. Aust. ii., 127—in the note as R. Cunningham's specimens. It is quite a distinct species, differing from *P. echinula* in having

shorter leaves varying from slightly incurved to somewhat recurved, some specimens showing almost straight leaves, while *P. echinula* has regularly, much incurved, leaves.

Flower heads are not so dense, bracts are not divided into long spreading subulate points, and the calyx is pubescent without acuminate lobes The bracteoles are linear, slightly keeled, and hairy, while *P. echinula* has glabrous bracteoles, triangular, acuminate, at the base somewhat clasping the pedicel. The petals are all yellow, and the ovary is silky villous, not glabrous as in *P. echinula.* The pod is nearly 3 lines long, and 2 lines broad, oblique ovate, somewhat flat, and scantily beset with long hairs.

Its position is between *P. Bauerleni*, F.v.M., and *P. echinula.* It bears much resemblance to the former in leaves, stipules, and inflorescence, but its calyx is very different, and the bracteoles are very small, whereas those of *P. Bauerleni* are broad and nearly 4 lines long.

Wentworth Falls, Blue Mts. J. H. Maiden, Oct., 1918 J H. Camfield, Nov., 1898.

EXPLANATION OF PLATES VI. and VII.

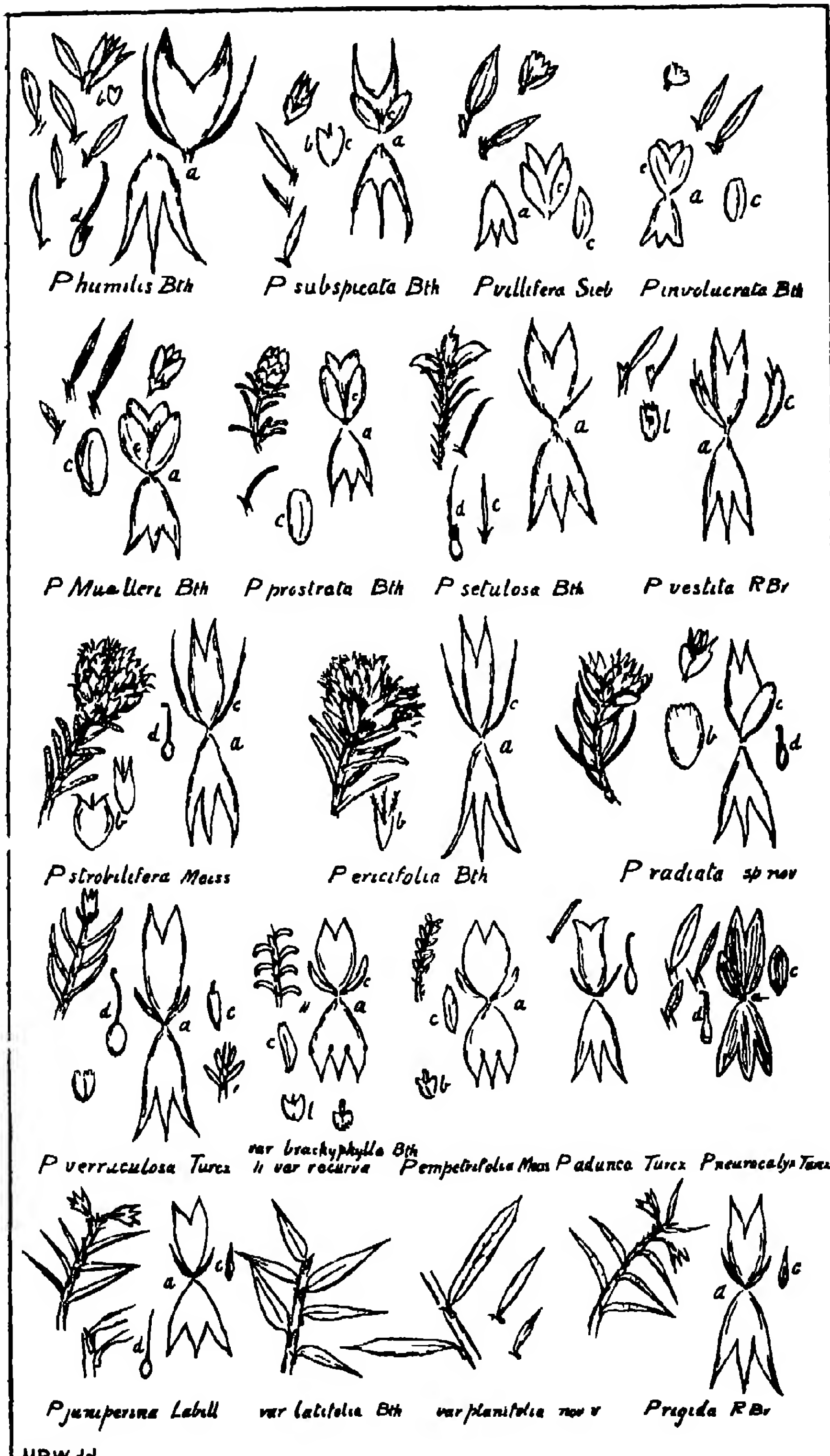
(a) Calyx lobes x 2
(b) Bracts x 2.
(c) Bracteoles x 2
(d) Ovary and style x 2.

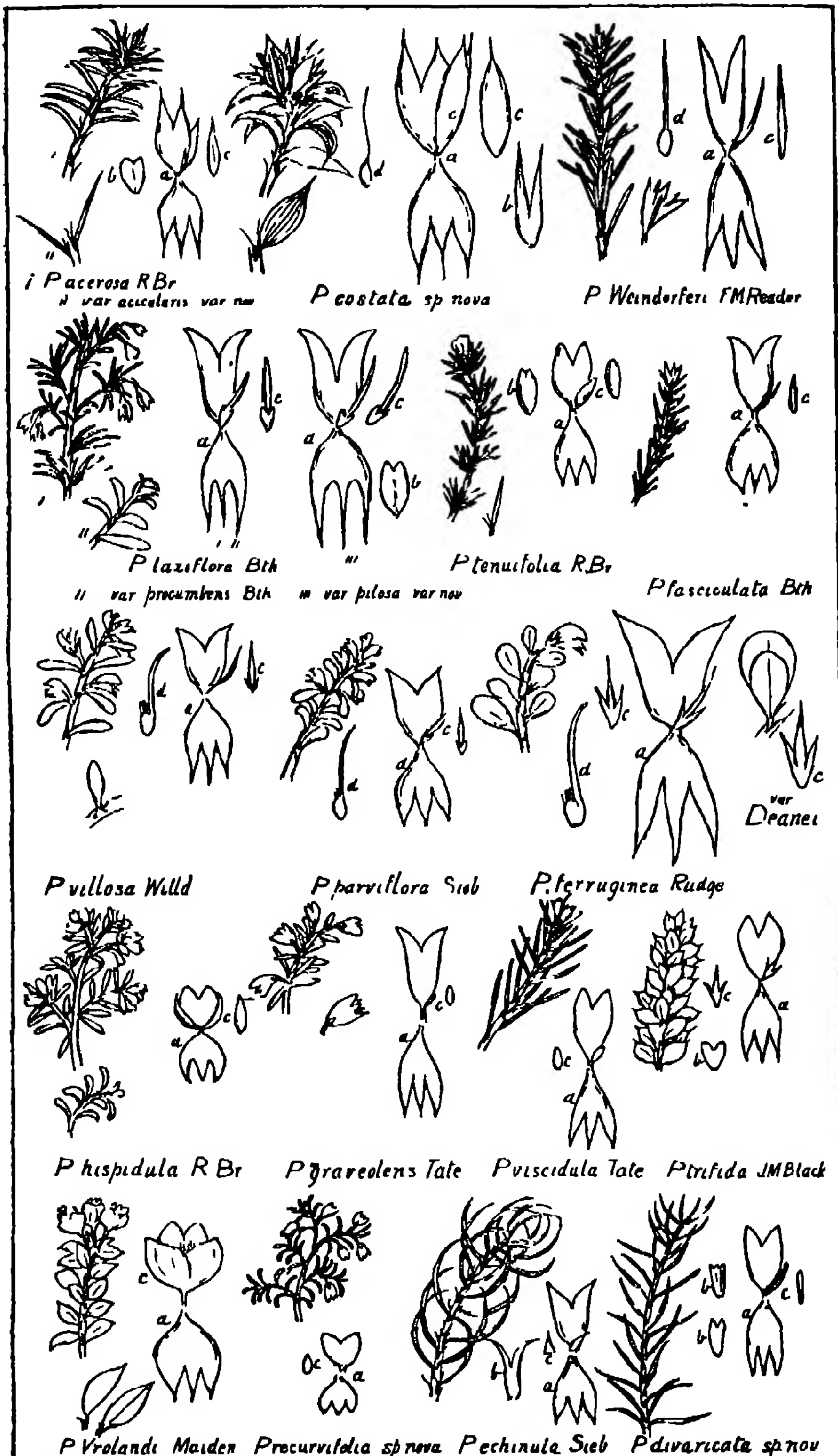
CORRECTIONS AND ADDITIONS.

On p 214 of Vol xxxii. of the Proceedings—

For *Pultenaea petiolaris*, Cunn. read *Pultenaea polifolia*, Cunn , and add: Port Jackson, Blue Mountains, Bondi Dist., New South Wales, Mitta Mitta, Victoria (S. F Clinton).

For *Pultenaea polifolia*, Cunn. read *Pultenaea petiolaris*, Cunn., and add. Rockingham Bay, Burnett R , Brisbane R , Queensland


P humilis Bth
P subspicata Bth
P villifera Sieb
P involucrata Bth
P Muelleri Bth
P prostrata Bth
P setulosa Bth
P vestita RBr
P strobilifera Meiss
P ericifolia Bth
P radiata sp nov
P verruculosa Turcz
var brachyphylla Bth
li var recurva
P empetrifolia Meiss
P adunca Turcz
P neurocalyx Turcz
P juniperina Labill
var latifolia Bth
var planifolia nov v
P rigida RBr
HBW del


i P acerosa R Br
ii var acicularis var nov
P costata sp nova
P Weindorferi F M Reader
P laxiflora Bth
ii var procumbens Bth
iii var pilosa var nov
P tenuifolia R Br
P fasciculata Bth
var Deanei
P villosa Willd
P parviflora Sieb
P ferruginea Rudge
P hispidula R Br
P graveolens Tate
P viscidula Tate
P trifida J M Black
P Vrolandi Maiden
P recurvifolia sp nova
P echinula Sieb
P divaricata sp nov
H B W del

[Proc. Roy. Soc., Victoria, 33 (N.S.), 1921.]

Art. XI.—*Description of Bracebridge Wilson Collection of Victorian Chitons, with Description of two new Species.*

By EDWIN ASHBY, F.L.S., M.B.O.U.

(Communicated by J. A. Kershaw.)

(With Plate VIII.)

[Read 11th November, 1920.]

Mr. J. A. Kershaw, Curator of the National Museum, Melbourne, has placed the collection of Chitons, made by the late Mr. J. Bracebridge Wilson in connection with the Port Phillip Exploration Committee of the Royal Society of Victoria, in my hands for examination and re-identification.

This collection was dealt with in a very able manner by Mr. E. R. Sykes, B.A., F.Z.S., etc., in his paper entitled "Report on a Collection of Polyplacophora from Port Phillip, Victoria, (Proc. Mal. Soc., vol. ii., pt. 2, July, 1896.)

Since that time a great deal of excellent work has been done in Australian Chitons by quite a long list of earnest workers. In view of this more recent work, some of Mr. Sykes' identifications have to be altered. Probably in some cases he had not at that time had any opportunity of seeing actual specimens, and depended solely on descriptions for his identifications, an example of such a case being his identification of *Ischnochiton tateanus*, Bednall.

The specimens are preserved in spirit, but many are badly stained, and the valves and girdle scales disarticulated or broken away. The collection, considering the comparatively small number of specimens, is a most remarkable one, containing an extraordinary percentage of rarities.

Of the twenty-two species identified by Mr. Sykes, he described five as new, all of which are still amongst our rare, and some amongst our rarest, Chitons; but in addition to these five, were four other new species mis-identified by Sykes, and although all

of them are well-defined species, they were not described for a good many years subsequent to the production of Mr. Sykes' paper.

Lepidopleurus.—Specimens belonging to this genus are dealt with towards the close of this paper.

Callochiton rufus, Ashby (Trans. Roy. Soc. of S. Aust., vol. xxiv., pt. ii., p. 86), mis-identified by Sykes as *C. platessa* Gould. This specimen is considerably smaller than the type which was described by me, 3rd September, 1900. It is a wonder that so good an observer as Mr. Sykes overlooked the deep pits or grooves that traverse the pleural area in the median valves—a feature that so clearly distinguishes this species from *C. platessa*, Gl. Possibly it was only examined when wet, as this feature might then be easily overlooked. Unless the specimen taken by Dr. Thiele in Western Australia is referable to this shell, previously to this identification the type was unique. As both were dredged it is undoubtedly a deep water species, and a very interesting addition to the Victorian fauna. Sykes says that he examined it with specimens in the British Museum, named *C. platessa*, Gould, which raises the question as to the possibility of the shell I named *rufus* being the same shell that Gould called *platessa*. But this contention seems quite out of the question, for, while *C. platessa*, or the shell we have been in the habit of calling by that name, is quite common at Port Jackson, the shell we are now discussing is not known from that locality at all. A reference to Gould's description in his "Otia Conchologica," which I now append, supports this view, for he makes no reference to the deep grooves so characteristic of *C. rufus*. The following quotation covers all his reference to the pleural areas in which the deep grooves are situated: "Areis centralibus lineis confertis acutis granulatis arcuatim decussatis." As compared with *platessa* this specimen shows three distinct longitudinal grooves, which are absent in the former species, the shell is more carinated than *platessa*, lateral area more raised, is more beaked, also the girdle scales are broader and shorter than *platessa*. It corresponds with type of *C. rufus*, Ashby, except that it is a juvenile, one-quarter the size, and is more beaked than the type.

Stenochiton pallens, Ashby. Mis-identified by Sykes as *S. juloides*, Ad. and Ang. Curiously enough this species was described by myself in the same paper as the previous one. The few specimens known have all been dredged. Messrs. Gatliff and Gabriel sent me this specimen to compare with the type in

1917, and they corrected the mis-identification of Sykes in vol. xxx., pt. i., of these Proceedings.

Ischnochiton torri, Iredale and May, appears in Sykes' paper as *Ischnochiton ustulatus*, Reeve.

Note.—Mr. W. L. May has referred me to a note contained in a letter addressed to himself by Mr. Tom Iredale on 26th April, 1916, which reads: "*Ustulatus*, Reeve, has girdle scales almost as large as *decussatus*, and specimens dredged in Port Phillip almost exactly agree. Sykes recorded it, and I think he was right." Mr. Jas. A. Kershaw has been good enough to return to me for further examination the specimen Sykes so determined, as, in the first examination, I cannot remember having paid particular attention to the girdle scales. This second examination confirms my earlier determination; the scales are quite typical, and it in every respect corresponds with the South Australian shells named by Iredale and May *Ischnochiton torri*.

Ischnochiton crispus, Reeve. Identified as such by Sykes. Specimens are large, not very well preserved, typically varied, one form being described by Sykes as variety *decoratus*. Type No. 890.

Ischnochiton crispus, Reeve, var. *decoratus*, Sykes.

Ischnochiton falcatus, Hull, mis-identified by Sykes as *I. tateanus*, *Bed*. While this interesting shell, so well described by Mr. A. F. Basset Hull, is easily separated from *I. tateanus*, a good many workers have at times confused them. The latter has the serrations of posterior margins of median valves "file like," and *falcatus* straight.

Ischnochiton wilsoni, Sykes. Type One of Sykes' new species, and a very fine one too, and still a rarity.

Ischnochiton iredalei, Dupuis, Auct. *lineolatus*, Blainville. Iredale and May, Auct., *contractus*, Reeve, Pilsbry, and identified as *I. contractus*, Reeve, by Sykes. Many of these specimens are so stained that identification is not very accurate

Ischnochiton virgatus, Reeve. Marked in Sykes' list as *Ischnochiton* (?) sp.

Ischnochiton (*Haploplax*) *pura*, Sykes. Type. This is still a rare species, and up to the present, only taken in Victoria.

Ischnoradsia evanida, Sowerby. Identified by Sykes as *I. australis*, Sow., of which it is a sub-species.

Heterozona cariosus, Pilsbry. A good series identified under this name by Sykes.

Plaxiphora albida, Blainville, syn. *petholata*, G. B. Sby., and so identified by Sykes.

Acanthochiton bednalli, Pilsbry. One specimen only, correctly identified by Sykes.

Acanthochiton pilsbryi, Sykes. Type. After careful cleaning this type specimen was found by the writer to be conspecific with *A. maughani*, Torr and Ashby, and fully described by him in Trans. Roy. Soc. of S. Aust., vol. xliii., 1919.

Acanthochiton gatliffi, Ashby. This specimen was marked (?) *A. bednalli*. A second specimen is in the collection (9 G.P.B.) mis-identified by Sykes as *A. bednalli*. I have placed this in a separate capsule. Of these two specimens one is in fair condition, the other eroded. It is remarkable that these specimens have for so many years been in this collection, and yet no worker has noticed their distinguishing characters. I only described this species last year from a specimen collected by myself at Port Lincoln, South Australia.

Acanthochiton (*Notoplax*) *matthewsi*, Bed. and Pils. Identified as such by Sykes.

Acanthochiton (*Notoplax*) *speciosus*, H. Adams. Identified as such by Sykes.

Acanthichiton wilsoni, Sykes. Type. Afterwards described by Dr. Torr under the name of *levis*, which becomes a synonym. This is a very fine species. The little, somewhat eroded specimen numbered 909 is, I think, referable to this species, but no mention is made of it in Sykes' paper.

Acanthochiton (*Notoplax*) glyptus, Sykes. Type. This is in some respects, I think, the finest of all our Australian *Acanthochitons*. As far as I am aware, only three specimens have been taken since Sykes' description was written, all three being taken by Mr. Gatliff in Victoria.

Cryptoplax striatus, Lamark. So identified by Sykes.

Rhyssoplax bednalli, Pilsbry. Identified as such by Sykes. This fine Chiton is still exceedingly rare I have only taken a single valve myself, and I believe all the very limited shells known have been dredged. The sculpture coincides so closely with *R. exoptandus* as to suggest that it is a deep water form of that species.

Rhyssoplax tricostalis, Pilsbry. Wrongly identified by Sykes as the New South Wales shell, which had been described by A. Adams under the name of *Chiton muricatus*, a name which Sykes points out in his paper was pre-occupied, and he adopts Carpen-

ter's manuscript name of *limans* in place thereof, calling the specimens in the Wilson collection *Chiton limans*, Sykes, and giving no fresh description. A careful examination reveals the fact that the specimens to which Sykes attached the name of *limans* are really Pilsbry's shell, *R. tricostalis*, named two years earlier than the issue of Sykes' paper, the pointed scales "sub erect apices" of the shells from Port Jackson, to which Carpenter's manuscript refers, are not present in the specimens in this collection.

RHYSSOPLAX JACKSONENSIS, n.sp.

Non *Chiton muricatus*, Tilesius (Mem. Ac St. Petersb. (1st ser.) ix, p 483, t 16, f 3, 1824. See Middendorf, Mal. Ross., p. 129). *Chiton muricatus*, A Ad. (P.Z.S., 1852, p. 91, t. 16, f. 6), not of Tilesius. *Lophyrus muricatus*, Angas (P Z S, 1865, p 186, 1867, p 222), not of Tilesius. *Chiton limans*, and *Chiton carnosus*. Carpenter MSS., is a nomen nudum. *Chiton muricatus*, A. Adams of Pilsbry (Man. Con xiv., p. 175, pl. 37, fg. 12, 13, 1892), not of Tilesius. Non *Chitans limans*, Sykes (Proc Mal. Soc., vol. ii., pt. 2, p. 93, July, 1896), which is not *limans* of Carpenter, but = *Chiton tricostalis*, Pilsbry (Naut., vol. viii., p. 54, 1894).

Introduction.—The discovery that the shells in the Wilson collection which Sykes named in 1896 as *Chiton limans*, Sykes, were really a shell described two years earlier by Dr. Pilsbry, under the name of *Chiton tricostalis*, leaves the New South Wales shell still without a name.

The name *muricatus*, given to this shell, by Adams, and adopted by both Angas and Pilsbry, as shown above, was preoccupied. Carpenter's MSS. name of *limans* cannot now be used. *Chiton limans* of Sykes now becomes a synonym of *Rhyssoplax tricostalis*. I therefore propose to name this familiar New South Wales shell *Rhyssoplax jacksonensis*, Ashby, after the famous harbour in which I collected the type.

Description.—The following is Pilsbry's description, under the name of *Chiton muricatus*, A.Ads., and it is, I believe, a transcription from Carpenter's manuscript. It is such an excellent description of the shell I have selected as type, that I copy it in full, supplementing it with a few additional notes of my own:—

"Shell oval, elevated, the jugum acute; mucro median, subprominent; olivaceous, maculated with paler; entire surface

minutely punctate; central areas having about 14 grooves on each side, obsolete in the middle; lateral areas having two riblets, sometimes bifurcating, or with another itercalated, furnished with strong acute tubercles, interstices smooth; end valves with 10-20 such riblets.

"Interior.—Anterior valve having 8, central 1, posterior valve 9 slits; teeth normal; sinus moderate; with about 15 denticles. Girdle furnished with large and small, wide, distinctly striated, elevated, acutely pointed scales. Length 23½, breadth 12½ mm., divergence 100°."

The shell I have selected as the type measures 19 x 9 mm., but the girdle is not well spread out; another given to me by Mr. A F Basset Hull measures 19 x 11 mm. It will be seen that these are slightly smaller than the measurements given by Pilsbry, and the number of ribs are proportionately less. Some of the ribs in the end valves bifurcate in my specimens. The ribbing in the central areas differs slightly from normal *tricostalis* of a similar size, in that they are narrow ridges, equally raised on both sides, whereas in *tricostalis* one side is more sloping, more of the nature of "weather boarding," but in both species there is a considerable range of divergence.

Variation.—The strong acute tubercles of the lateral ribs are much modified in some specimens Instead of being "sharp pointed tubercles," they are mere ridges, in this respect approaching more closely to *tricostalis*. Carpenter's manuscript name, *carnosus* probably referred to this varient. In the specimen I have chosen as type, these tubercles are characteristically sharp-pointed. In colour, there is also a considerable variation; one specimen has end valves, the whole of the ridge, and several lateral areas, pink, two valves have dark brown lateral areas and two cream Another, not now in my collection, was mostly cream, touched up with pink.

Habitat—All my specimens came from Port Jackson; the one I have selected as type I collected in the Quarantine Station there on 23rd November, 1918.

The type remains in my collection for the present, but it is intended that it shall ultimately be placed in the South Australian Museum

Note.—This shell can easily be distinguished from *R. tricostalis*, Pils., and *aureo-maculata*, Bed. and Mat., by the pointed girdle scales, this feature being so prominent that it can be noted without the aid of a lens.

LEPIDOPLEURUS.

There are two species of this genus represented in the collection. So many points of interest are involved in their identification, that they almost want a paper to themselves.

Messrs. Iredale and May, in their valuable paper (Proc. Mal. Soc., vol. xii., pts. II. and III., Nov., 1916, p. 99), discuss the question of the identification of Reeves' *Lepidopleurus inquinatus*, described as from "Van Dieman's Land; Dr. Sinclair," and conclude their discussion with these words: "However, all those we have yet examined seem to fall into *Parachiton*, since the girdle appears to be covered with slender glassy spikes, while *inquinatus* and the Neozelandic shore shells have the girdle covered with small scales," and add, "There may be a shore shell in South Australia which may bear the name of *liratus*." I show later on in this paper that, while all the species under discussion have girdles furnished with scales, they also, all, in a varying degree, have some spicules present as well It is not at all difficult to understand why Reeves and Adams and Angas should have ignored this feature when one has seen how easily these spicules disappear, or become a negligible quantity in shells kept a long time in spirit, or that are carelessly preserved.

I have gone carefully into this question, comparing the material I have available with Reeves' description and plates of *L. inquinatus* and Adam and Angas' description of *L. liratus*, and I have come to the conclusion that we are amply justified in recognising in the South Australian shore shell the *Lepidopleurus liratus* of Ad. and Ang., and endorse the action of Sykes in recognising in some of the specimens from Port Phillip Reeves' *Chiton inquinatus*, which shell coincides with one of the forms dredged in Tasmania by Mr. W. L May I now separate the Neozelandic shell describing it under the name o *iredalei*, in acknowledgment of the suggestive remarks quoted above.

Lepidopleurus liratus, Ad and Ang (P Z.S, London, 1864, p. 192, Angas l.c. 1865, p. 187)

There are two small specimens which I consider correspond with the shore shell found, although never numerous, in all places in South Australia where I have collected It is quite evident that the shell collected by Angas, "Under stones at low water, Yorke's Peninsula, South Australia," is the one that has been known in collections from that State as *L. inquinatus*, Reeve, but was included in my Distribution List (Trans. R. Soc.

of S. Aust., vol. xlii., 1918), under the name of *L. liratus*, Ad. and Ang., and I propose now to recognise it as such. I append in full the original description, as quoted by Pilsbry, Man. Conch. xv., p. 101: "Shell small, elongated, convex; yellowish brown, maculated with pale brown, end valves and lateral areas concentrically remotely sulcated, densely and minutely lirate, the lirae closely pustulose. Posterior valve elevated, lateral areas slightly elevated, median valves obtusely carinated in the middle; dorsal areas longitudinally lirate, the lirae closely pustulose. Girdle pale brown, densely covered with minute scales. Length 8 mm., width 4 mm. Yorke's Peninsula, South Australia, under stones at low water."

To this description I would add, the girdle is clothed with minute, irregular, mostly rather long, scales, often placed at different angles. It has a girdle fringe of spicules, and scattered spicules occur in a varying degree in different specimens. This probably constitutes a first record for the State of Victoria for this species.

Mr. Sykes did not, in his paper, distinguish this shell from those he identified as the following species

Lepidopleurus inquinatus, Reeve (Con. Icon., Reeve, pl. xxiii., f. 154), of which the following is a transcription of the original description.

"*Chiton inquinatus*, the Solid Chiton. Shell oblong-ovate, terminal valves, and lateral areas of the rest concentrically, somewhat obscurely ribbed, finely, radially grooved, central areas longitudinally, finely ridged; ligament, horny, arenaceous, whitish, stained with light brown spot along the summit of each valve. Hab.—Van Dieman's Land; Dr. Sinclair This shell is sometimes partially stained throughout with the faint brown colour which appears on the umbonal summit."

Mr Sykes, in his paper aforesaid, page 86, identifies these specimens, of which there is a nice series, as Reeve's *inquinatus*, and says:—"Having had the advantage of separating the valves of one of Reeves' specimens, I am able to be positive of the identification."

As compared with the previous species, the granules in the longitudinal ribbing are smaller, less raised, and have a smoothed or planed off appearance. Perhaps the sculpture will be best described as ribs formed of strings of coalesced granules, whose upper sides are flattened, thus forming a continuous rib. The dorsal area is similar in sculpture, except that the ribbing is

narrower and more closely packed. The lateral areas are much raised, similar in sculpture to the other areas, but radial, the lines of growth in this area are marked by very coarse, concentric ribbing, or undulations, differing but little in this respect from those of *liratus*, Adams and Angas. In some of the valves the sculpture, especially towards the posterior margin, is smooth and highly polished, in this respect coinciding with the New Zealand shell.

The largest specimen, without the girdle, which is too incurved to measure, is 26 x 7 mm. In this specimen, the granules are more defined, especially in the lateral areas, and the smooth, highly polished character seemed absent.

Girdle.—While some of the specimens, in addition to the girdle fringe, have a few scattered spicules, the largest is almost free from them. The girdle in all is covered with minute scales, which are well described under the term arenaceous, the term used by Reeve. In this they differ from the preceding species, and still more widely from the Neozelandic shell.

In conclusion.—Mr. W. L. May has been good enough to lend me a specimen which he dredged in 15 fathoms in the Schouten Passage, Tasmania, adhering to shell. This is identical with the Port Phillip shells under review, although the girdle is a little more spiculose.

I cannot see any justification in assuming that Reeve's locality of Tasmania was a mistake, and that it should have been New Zealand. The character he gives of the girdle scales certainly fits this form, and not the Neozelandic shell. The only difficulty is the omission in the original description of any mention of spicules in the girdle This may easily be accounted for as in some specimens they seem barely present at all. I therefore propose to reinstate Reeve's *inquinatus*, giving as its habitat, deepish water in Tasmania, Victoria and South Australia.

LEPIDOPLEURUS IREDALEI, n sp.

The recognition of Reeve's *Chiton inquinatus* as one of the Australian shells, makes it necessary to describe the New Zealand shell under a new name, and as Mr. Tom Iredale's remarks before quoted, are a contributing factor towards the recognition of Adams and Angas' *L. liratus*, I think it is only just that the Neozelandic shell, which has so long been known under the name of *L. inquinatus*, Reeve, should bear Mr Iredale's name, and therefore I have pleasure in calling it after him.

Lepidopleurus iredalei differs from *L. inquinatus*, Reeve, in that the girdle is clothed with comparatively large, flattened, irregular scales, quite different from the Tasmanian shell, in which species the scales are like minute, irregular grains of sand. In common with the other species, the girdle is furnished with a spiculose fringe, but in some of the specimens before me the girdle is almost otherwise bare of spicules. Evidently this character is not constant, for the specimen I have selected for the type has small bunches of spicules at the sutures, and in several of the others this feature is just discernible in a few places. Mr. Iredale must have overlooked this character when he placed the Neozelandic shell, and Reeve's *inquinatus* among the group that have no spicules.

Undoubtedly the New Zealand shell is barely spiculose as compared with some of the Australian species, but, as I have shown, spicules are not entirely absent. It seems doubtful whether the non-existence of spicules is a sufficient ground for generic or sub-generic separation in the *Lepidopleuridae*, for the range of divergence in this respect is very great, even in the same species.

To sum up—*L. liratus*, Ad. and Ang. is more spiculose than *L. inquinatus*, Reeve, and the latter is more spiculose than is the case with the Neozelandic shell. The latter is more rounded than the Tasmanian, and the polished appearance is more persistent.

Colour.—The dark specimens vary from liver brown to hazel (plate xiv., Ridgway's Colour Standards), and the lighter colour in the paler forms is cinnamon (pl. xxix).

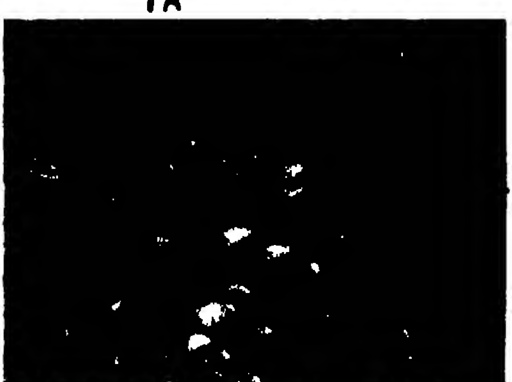
Measurement.—The largest of the specimens before me is 14 x 7 mm., and the one I have selected as the type, because it shows the sutural spicules more distinctly, is 8 x 4½ mm , dry specimens.

Habitat.—The type is from Doubtless Bay, New Zealand, collected by Mr. Albert E. Brooks, to whom my acknowledgments are due for the specimens.

I cannot separate the Doubtless Bay specimens from one from Auckland Harbour, collected by the late Mr. Suter in 1895. The type, for the present, remains in my possession.

1A

3A



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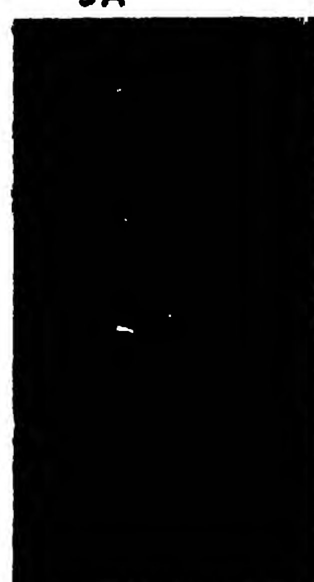

3B

1B

DESCRIPTION OF PLATE VIII.

Fig. 1a. *Rhyssoplax jacksonensis*, Ashby. Shell, x nearly 5.
" 1b. " " showing pointed girdle scales, x 28
" 2. *Rhyssoplax tricostalis*, Pilsbry, showing girdle scales, x 28.
" 3a. *Lepidopleurus iredalei*, Ashby Shell, x 10
" 3b. " " showing portion of valves and flat, irregular, girdle scales, x 28.

[Proc. Roy. Soc. Victoria. 33 (N.S.), 1921].

Art. XII.—*Researches into the Serological Diagnosis of Contagious Pleuro-Pneumonia of Cattle.*

By G. G. HESLOP, M.V.Sc., D.V.H.
(Walter and Eliza Hall Fellow).

(Communicated by Professor H. A. Woodruff.)

[Read 9th December, 1920.]

Introduction.

Contagious pleuro-pneumonia was introduced into Australia by the importation into Victoria of an infected cow from Great Britain in 1858. Soon after its introduction into Australia the disease spread with alarming rapidity, and in a very short time it had become disseminated through every State in the Commonwealth.[1]

At the present time the disease exists in each of the Australian States, with the single exception of Tasmania, which, owing to its geographical situation, has been able, by the adoption of rigid quarantine restrictions, to prevent introduction from the mainland.

In Victoria an active policy has been adopted by the State Veterinary Department, in dealing with outbreaks; the measures adopted being strict quarantine of infected and incontact herds, the slaughter of all visibly infected animals, isolation of all doubtful cases, and prophylactic immunisation by inoculation of virus subcutaneously in the tail of all contacts.

That these measures have proved inadequate to free the State of pleuro-pneumonia, and keep it free from the disease is evidenced by the occasional outbreaks which occur from time to time in various portions of the State. On the other hand, their application has been attended with a considerable amount of success, and any relaxation of them is immediately followed by an extension of the disease throughout the State.

As an instance: During the late war, owing to the absence on active service of the majority of the members of the State

1. W. T. Kendall (1913), "Notes on the Early History of the Veterinary Profession in Victoria." Report of the 14th meeting of the Australasian Association for the Advancement of Science, p. 704.

Veterinary service, it became necessary for the Department of Agriculture to modify and relax the usual method of dealing with outbreaks of contagious pleuro-pneumonia. It is a significant fact, that during that war period, the disease became more prevalent throughout Victoria than it had been for many years.

As far as Victoria is concerned, the difficulties of control and eradication are enormously increased by the border traffic in animals from neighbouring States, and the impossibility of recognising, by clinical examination alone, the presence of carriers of latent infection.

The records obtained over a number of years in Victoria show the large percentage of outbreaks of the disease, which owe their origin to the unsuspected introduction of a carrier of the infection into a healthy herd. The diagnosis and destruction of these so-called "recovered animals," carriers of a potential infection, which readily becomes actual when they come in contact with susceptible animals, is therefore a matter of prime importance in successfully eradicating the disease from any particular State.

In certain European countries, notably Great Britain, and in the U S.A., the disease has been eradicated by adopting the procedure of wholesale slaughter of all the animals concerned in each and every outbreak. This procedure, whilst economically justifiable in those countries with our present knowledge of the disease, is at the same time unscientific and costly, since it necessitates the destruction of a very large number of healthy cattle in order to attain its object.

The difficulties of adopting such a course of stamping out the disease in Australia at the present day are obvious, owing to the large area over which the disease has spread, the scattered nature of the outbreaks, the number of cattle, the slaughter of which would be involved in such stamping out process, the enormous cost of compensating the owners of the slaughtered animals, and also owing to the existence of the disease on stations situated in the more remote parts of Australia, where it would be impossible to muster all the cattle on the particular property at any one time.

The variable incubation period, which may be anything from 10 to 30 days, and the fact that an animal affected with the disease, but not showing recognisable clinical signs of such infection, may be an actual infective agent, renders the task of localising outbreaks exceedingly difficult. The role played in the dissemination of the disease by so-called "recovered animals,"

adds a further complication to the effective eradication of the disease from any particular State. These "recovered animals" are capable of retaining the infective agent in a latent form for at least several months, and the unsuspected introduction of such animals into healthy herds often provides the starting points of fresh outbreaks.

Thus, apart from animals in which the disease can be recognised by the clinical symptoms alone, the disease is mainly propagated by "carriers" (so called "recovered" animals), or by affected animals in which the usual clinical signs of the disease are not apparent. The importance of eliminating such animals as early as possible from herds in which the disease has appeared, and the difficulty of attaining the desired object when one has recourse only to the usual clinical methods of diagnosis, made it essential that some more searching and reliable diagnostic method should be elaborated, which could be applied to such cases, in order to detect them. It was mainly with the object of attempting to arrive at such a diagnostic method that this present research work was undertaken.

I desire to express my grateful appreciation and thanks to Dr. S. S. Cameron, Director of Agriculture, Victoria, and to Mr. W. A. N. Robertson, B.V.Sc., Chief Veterinary Officer, Department of Agriculture, Victoria, for the opportunity and assistance they have granted me to pursue the study of contagious pleuro-pneumonia uninterruptedly for close upon twelve months

To the staff of the Live Stock Division, Department of Agriculture, Victoria, I am indebted for the collection of blood samples from infected and non-infected animals, and for post-mortem records of the animals supplying the various sera tested

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Historical Résumé.

The earliest conception of the etiology of pleuro-pneumonia was that cold was the primary cause operating in the production of the disease.

In 1852 Willems (20)[2] as a result of a number of observations and experiments, demonstrated that the disease was contagious, and that healthy animals had to come into close contact with diseased animals before the disease would spread from one to the other. He further demonstrated that, in order that the disease could spread, it was necessary for contact to be between living animals. The disease was not spread when healthy animals were exposed to contact with the carcase of an animal which had died from contagious pleuro-pneumonia. His experiments with pleuritic serosity are of special interest, as they mark the commencement of a system of immunisation against the disease, which system, with but very slight modifications, is extensively practised at the present day. Willems found that if a small quantity of pleuritic serosity, taken from an animal affected with pleuro-pneumonia, was injected subcutaneously behind the shoulder of a healthy animal, there followed, after an incubation period varying from 8 to 15 days, a firm swelling, later becoming fluctuating, hot and painful, which then rapidly increased in size, and gave rise to an invading oedema of the whole of the connective tissue in the region of the inoculation This swelling contained a large quantity of clear amber-coloured serosity, a small quantity of which injected into another healthy bovine animal behind the shoulder gave rise to a similar swelling at and around the site of inoculation. Death of the experimental animals almost invariably followed these experimental inoculations behind the shoulder, but when inoculations with the same materials were made subcutaneously in the tail, a few centimetres from the tip, there followed a mild reaction, with some swelling of the tail, which usually subsided in the course of 15 to 21 days, but which occasionally terminated in a more or less extensive

2. Reference is made by numbers to "Literature Cited," pp. 63-65.

necrosis of a portion of the tail. These benign reactions, he announced, were productive of a marked degree of immunity against natural infection with the disease At no time, as a result of these inoculations, either behind the shoulder, or in the tail, was he able to demonstrate that they gave rise to a definite pleuro-pneumonia of the lungs, similar to that seen in animals naturally infected He noticed, however, that the swelling produced as a result of the subcutaneous injection of lymph behind the shoulder had many features histologically comparable with the condition set up in the lungs by natural infection.

In 1883 Pasteur (16) carried out some experiments with the so-called "lymph" (pulmonary and pleuritic exudate), and he declared that the lymph contained pure virus, which could not be cultivated on ordinary media

"Sussdorf (1879), Bruylants and Verriest (1880), Putz (1881), Himmelstoss (1884), Lustig (1885), Poels and Nolen (1886), isolated and described various microbes without establishing their specificity" (12)[1]

In 1895 Arloing (1) isolated from cases of pleuro-pneumonia a short non-motile bacillus, which he named the pneumo-bacillus-liquefaciens-bovis, and which he claimed was the causal organism of pleuro-pneumonia. Pure cultures of this organism, according to Arloing, when introduced intra-pulmonarily into healthy animals, were capable of producing the characteristic lung changes seen in naturally infected cases of pleuro-pneumonia, while subcutaneous injection of pure culture into susceptible animals produced immunity. Arloing's experiments are open to a considerable amount of criticism, owing to the technique he employed, and although his experiments were repeated by others, his announced results could not be confirmed.

In 1898 Nocard and Roux (13), by means of an ingenious experiment, succeeded in artificially cultivating the virus of pleuro-pneumonia in bouillon contained in collodion sacs, which were inoculated with a trace of pulmonary serosity from an animal affected with pleuro-pneumonia, and were then embedded in the peritoneal cavities of rabbits. After 15 to 20 days the bouillon, which at the commencement of the experiment was perfectly limpid, showed a faint opalescence, and thereafter the rabbits became emaciated. The contents of control sacs similarly treated, but not inoculated with serosity remained perfectly clear and

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[1] P. 4[illegible].

sterile, and the rabbits remained healthy. There were confined in the sacs containing the opalescent medium no bacteria capable of cultivation on the ordinary laboratory media. Under microscopic examination, with a high magnification (1500-2000 diameters), and with an abundant illumination, there was observed in the opalescent culture medium a number of very small and refringent points, so small that their individual structure could not be accurately determined.

Shortly after the discovery of the causal organism of contagious bovine pleuro-pneumonia by Nocard and Roux, the disease engaged the attention of a number of scientists in various parts of the world. In 1900 Dujardin-Beaumetz (6) published his thesis on the isolation and cultivation of the organism discovered by Nocard and Roux, which he showed could be grown *in vitro* in a special medium, consisting of Martin's peptone bouillon, with the addition of serum. The organism was capable of traversing Berkfeld and Chamberland F. filter candles provided the virus or culture was suitably diluted prior to filtration. On the contrary, the Chamberlain B. filter candles formed an impassable barrier to the organism, irrespective of the dilution employed. He also described the characters of the culture in special broth, and on solid media, and was able to provoke in cattle, by subcutaneous inoculation of pure culture in the trunk, a typical oedematous engorgement corresponding in all its appearances to that following the inoculation of lung virus into similar animals in similar situations.

In 1906 Dujardin-Beaumetz (7) succeeded in producing, with pure cultures of the organism in broth plus sheep's serum, and in broth plus horse serum, similar lesions in sheep and goats to those observed following the inoculation of culture in broth plus ox serum into cattle.

In 1910, Borrel, Dujardin-Beaumetz, Jeantet, and Jouan (4) described in detail the morphology of the organisms they had isolated from pure cultures. They remarked upon the polymorphism of the organisms in the preparations examined and described filamentous forms, chains, granules, round forms, ovoid forms, and pseudo-vibrion filaments. Asteroid forms in particular were described, and they suggested the name "Asterococcus mycoides" for the organism.

Bordet, in 1910 (2), also published the result of his observations concerning the morphology of the organism of contagious pleuro-pneumonia. He described granules and filaments re-

sembling spirilla and spirochetes, which originated from single granules.

Following closely on the work of Borrel, Dujardin-Beaumetz, Jeantet and Jouan, and on that of Bordet, Martinovski (8), in 1911, published an account of his observations of the organisms in cultures and in sections of diseased tissue. He also remarked upon the polymorphism of the organism, and after having described various forms, some of them similar to some of those observed by Borrel, he concludes that "the study of the pleuro-pneumonia microbe in the tissues of infected animals, and in the cultures, allows us to classify the microbe of Nocard and Roux in the group of cocco-bacilli, so that the name "Coccobacillus mycoides peri-pneumonic" would suit it well, as it indicates all the properties of this singular organism."[4]

K. F. Meyer (1909) (9) described in detail the pathological changes which occur in the lungs and other tissues in naturally infected cases of contagious pleuro-pneumonia, and also the changes which occur in tissues following a subcutaneous injection of virus in the dewlap or in the tail. He states:—"It is interesting to demonstrate that whichever tissue may have been the seat of injection of pleuro-pneumonia virus, it always shows exactly the same changes as have been described as being found in the interstices of the lungs under natural infection."[5]

It is of passing interest to note that Meyer, in referring to the complications such as necrosis of the tail, peritonitis, etc., which sometimes follow the inoculation of virus, remarks:—"It has been stated that contamination of the vaccine is the cause of complications. I quite disagree with such a notion, for working with absolutely pure cultures, and taking all aseptic precautions, we yet cannot avoid having losses. Individual disposition, or weakening of the constitution form the cause of the misfortune."[6]

Boynton (1912) (5) has shown, as a result of a close study of the muscular changes brought about by intermuscular injection of infected material into otherwise healthy bovines, that the lesions occurring in the muscles following such injections are histologically comparable with the lesions occurring in the lungs in cases of the disease naturally acquired.

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4. P. 917
5. P. 153.
6. P. 153.

It was to be expected that, following on the isolation and successful cultivation of the causal organism of contagious pleuro-pneumonia, attempts would be made to apply the usual serological reactions, such as agglutination, precipitation, and complement fixation, for the diagnosis of the disease in the living animal.

Dujardin-Beaumetz (1900) (6), after experiments with culture and serum from immunised bovines, announced that the "serum of hyper-vaccinated animals is not bactericidal, and agglutination is not able to be of any use in the diagnosis of pleuro-pneumonia." However, in 1906 (7) he found that massive intravenous injections of pure culture in Martin's broth plus horse serum into horses gave rise to agglutinins in the horse serum, which could be demonstrated in dilutions up to 1-50. Further he demonstrated that this same serum would give a precipitin reaction when combined with the serum of experimentally inoculated bovines, and he suggested that, although as a serodiagnostic method it was delicate in performance, it might be of some use in order to confirm clinical diagnosis in certain chronic cases of the disease.

Schochowsky in 1912 (18) published the results of his work on complement fixation in relation to pleuro-pneumonia. He concluded that it was impossible to obtain a reliable complement fixation reaction, and that complement fixation had no value as a serodiagnostic method for contagious pleuro-pneumonia. This view was also expressed, though not so definitely, by Poppe (1913) (17), who obtained unsatisfactory and contradictory results with his work on complement fixation. He found, however, that a precipitation test (Fornet's ring reaction), gave fairly reliable results, but that sera had to be specially selected to act as precipitinogen He concluded that the test could be used with advantage for the diagnosis of doubtful cases where the clinical evidence was insufficient.

K. F. Meyer (1914) (10), in a review of the filterable viruses in general, refers briefly to the more important work which has been done in recent years on contagious pleuro-pneumonia. He points out that "the study of the filterable viruses is attended with considerable technical difficulties, and the experimental results obtained depend largely on the ingenuity of the experimenter."[7] Referring to the complement fixation test in pleuro-pneumonia, he states:—"In some unpublished experiments the author found the complement fixation tests very unreliable for

7. P. 267.

the demonstration of an existing immunity in contagious pleuro-pneumonia of cattle. Only in one naturally infected animal could immune bodies be detected."[8]

Panisset (1914) (15) has also published a summary of our present knowledge of the filterable viruses in general, and in doing so, has covered much of the ground covered by Meyer in his review. It is interesting to note that Panisset in his summary states:—" L'immunisation contre les virus filtrants ne semble pas proceder des memes principes que l'immunisation contre les bacteries. Les phenomenes humoraux qui accompagnent l'etat d'immunite sont peu marques (agglutination, precipitation) ou manquent complement, on ne les observe bien que dans la peripneumonie qui a beaucoup d'egards est une maladie bien differenciee Cependant la fixation des sensibilisatrices du serum est assez souvent observee."[9]

Cultures.

The foregoing chapter is a short resume of the literature at my disposal when this research work was commenced. Although it seemed probable that any attempt to apply the agglutination or complement fixation tests for the diagnosis of contagious pleuro-pneumonia would not be successful, it was decided to proceed with the research work, more especially because no such work had been previously attempted in Australia. Accordingly, on 4/10/19, a commencement was made by obtaining virulent lung serosity from a naturally infected cow which was killed at the City Abattoirs, Melbourne. A small quantity of this lung serosity was collected under aseptic conditions in sterile Pasteur pipettes, and inoculated direct into ten tubes of Martin's peptone bouillon plus 7.5 per cent. normal ox serum, and placed in the incubator at 37°C. A further quantity of the lung serosity from the same animal was collected in a sterile bottle, and brought to the laboratory. This serosity was used later for an experiment to demonstrate the filter-passing properties of the organism of contagious pleuro-pneumonia.

Of the ten tubes inoculated direct with virulent lung serosity on 4/10/19, four showed obvious contamination after 36 hours' incubation, and were discarded. Of the six remaining tubes one proved sterile, the other five showed in from 4 to 6 days a faint

8. P. 284
9. P. 312.

opalescence in the culture medium. This opalescence was extremely slight, and could be best recognised by holding the tubes in such a manner that varying degrees of light fell upon them, at the same time comparing each tube with one or more control tubes of the same medium, which had been incubated, but which had not been inoculated. In order to recognise the presence of this slightly opalescent culture in Martin's broth serum medium it is absolutely essential that each lot of tubes inoculated and incubated should be efficiently controlled by incubating tubes of the same broth serum medium, which have not been inoculated, and comparing them from time to time.

Sub-cultures made into Martin's broth plus ox serum, and incubated at 37°C. showed in 3 to 4 days the same opalescent appearance noted in the primary cultures. This opalescence could still be obtained after several generations of subcultures.

Examination of stained films, made with this opalescent broth, under the microscope with a magnification of 1000 diameters, failed to reveal any recognisable micro-organisms, the material in the film staining as a homogenous mass.

In order to make sure that the opalescence in the broth was due to the growth of micro-organisms, sub-cultures from the broth tubes were made on to Martin's-broth-agar with sterile ox serum added after it had been sloped. On this solid medium very fine colonies developed in four days, at first only recognisable by means of a lens, but by the eighth day they assumed the size of a pin's point. More or less colourless at first, and appearing like drops of dew on the surface of the medium, they later on became slightly opaque. These colonies appeared on the surface of the agar, but were firmly embedded into it, and were dislodged with difficulty. In most cases they had to be dug out of the agar, so firmly were they attached. Several colonies were removed, and stained for microscopic examination *en bloc*. They stained readily with the basic stains, but were decolourised by Gram's method. Although the shape of the colony could be distinguished under the microscope, individual organisms could not be seen with a magnification of 1000 diameters.

Sub-cultures from the Martin's broth tubes were made into Martin's broth tubes containing 1 per cent. of various sugars —saccharose, glucose, maltose, lactose, and the alcohol derivatives—mannite and dulcite. In the mannite and dulcite tubes no growth took place. This experiment was subsequently repeated with other cultures of the organism inoculated into mannite broth

with a similar result. In glucose Martin's broth there is a very definite acid reaction developed. The acid reaction is apparent after the third day of incubation, and increases towards the eighth day, when it apparently attains its maximum, though it is apparent throughout the life of the culture. No gas is developed by the organism in this medium. In maltose Martin's broth there is also a very definite acid reaction produced by the organism, but no gas is developed. In lactose Martin's broth, and in saccharose Martin's broth, there is growth of the organism, but no acid or gas is developed. Tubes of each medium not inoculated, were incubated as controls, and showed an unaltered appearance on comparison with tubes of similar media, uninoculated, and not incubated. The reaction of the organism on cultivation in media containing various sugars can be summarised as follows:—

	Saccharose	Glucose	Maltose	Lactose	Mannite	Dulcite
Acid	—	+ +	+	—	No growth	No growth
Gas	—	—	—	—		

+ + Strongly acid

In order to obtain cultures it is an absolute rule that the culture medium must contain serum. In ordinary broth the organism will not develop. On ordinary nutrient agar the organism will not develop. No growth takes place on gelatine. For all growths obtained, Martin's peptone bouillon has been used as a basis for the medium, and various sera have been tried in various proportions. Growths have been obtained in Martin's broth, to which either ox serum, horse serum, or rabbit's serum has been added. No growths have been obtained in Martin's broth with guinea-pig's serum added, although several such tubes have been inoculated. Growths have been obtained in Martin's broth medium, in which the added ox serum did not exceed 3 per cent. It was found that about the most satisfactory serum content for the culture medium was 7.5 per cent., although very satisfactory growths could be obtained with slightly greater or lesser amounts of serum in the medium.

Filtration Experiments

Experiments were made to test the filter passing properties of the organism of contagious pleuro-pneumonia. Virus obtained from active lesions in the lungs of cattle, affected with contagious pleuro-pneumonia naturally acquired, which were slaughtered at the City and other Metropolitan Abattoirs, was mixed in varying

degrees of dilution with Martin's peptone bouillon (previously filtered without the addition of serum). The broth and virus were thoroughly mixed, and the mixture was then passed through a Chamberland F. filter at a pressure of 600 mm. of mercury. After all the broth-virus mixture had passed through the filter, the requisite quantity of normal unheated ox serum was filtered through the same filter into the broth-virus filtrate The resulting filtrate was then placed in the incubator at 37°C.

The whole operation of filtration was usually accomplished in under 1¼ hours, but the time depended, of course, on the quantity of material to be filtered. Usually not more than 250 c.c. of broth-virus mixture, followed by the requisite amount of serum was passed through the one filter at the one period of filtration.

A certain amount of difficulty was experienced in demonstrating the filtrability of the micro-organism, and a number of experiments had to be made before it was accomplished. Previous workers [10] have established the fact that, unless properly diluted in a definite proportion (not exceeding 2 per cent.), in a medium without the addition of serum previous to filtration, the virus will not pass through the filter, and a sterile filtrate will result. Although this percentage was not exceeded in any of my experiments (excepting for a special purpose in one series of experiments), a sterile filtrate often resulted, and it would appear that the passage of this organism through Chamberland F. filter candles, is not as easily accomplished as the statements of previous workers, would imply. It is to be regretted that, owing to the war, Berkfeld filters could not be obtained in Melbourne for this experimental work, because the passage of the organism through Berkfeld filters is apparently not attended with the same difficulties as the passage through the finer-grained filters such as the Chamberland F.

In order to prove that absence of growth in the filtrate was not due to changes in the medium brought about by the filtration, the filtrate of one experiment, which had shown no growth on incubation was distributed into four sterile flasks, two of which were then inoculated from a sub-culture of the organism of pleuro-pneumonia, the remaining two flasks being kept as controls

In the two flasks inoculated with the sub-culture, the characteristic opalescent growth was obtained after four days' incubation at 37°C., the two control flasks remained sterile.

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10. Nocard, Roux, and Dujardin-Beaumetz.

In order to prove that a culture obtained by primary inoculation of virulent serosity into Martin's broth plus ox serum, was filtrable, the following experiment amongst others was undertaken:—

Two c.c. of a third sub-culture, from a culture which had been obtained by primary inoculation of virulent serosity into tubes of Martin's broth, plus ox serum, at the time that the post-mortem examination was made, was diluted with 200 c.c.s., of Martin's broth, *without serum*, and filtered through a Chamberland F. filter. Fifteen c.c.s. of normal ox serum were then filtered through the same filter into the same filtrate, and the final resulting filtrate was well mixed and distributed into sterile test tubes, and incubated at 37°C Growth was apparent in 21 days. This experiment—or another similar to it, differing only in the quantities of broth, culture and serum employed (the ratio of culture to broth in each instance never exceeding 1 to 100)—was repeated later with a similar result, excepting that in the second instance growth was not apparent until after 25 days' incubation at 37°C. These experiments prove that the organism obtained in primary cultures by tube inoculations made at the post-mortem is capable of passing through a Chamberland F. filter when the culture is properly diluted with Martin's broth prior to filtration. These experiments have also demonstrated another important fact, namely, that while growth may be apparent in from 4 to 6 days following a primary inoculation of virulent serosity into Martin's broth plus ox serum at a post-mortem, growth is not apparent until from 21 to 25 days after a filtration experiment through Chamberland F. filter candles. The resulting growth in each instance, however, appears to have identical characters.

If the required quantity of serum is added to Martin's broth before filtration of the virulent material, the organisms will not pass through the filters. The Martin's broth used for diluting the virus or culture prior to filtration should first be passed through a Chamberland F. filter in order to facilitate the next filtration when the virus of culture is added. It has been demonstrated by my experiments, that a dilution of 1½ c.c.s. of culture in 100 c.c.s. of previously filtered Martin's broth without serum allowed the organism to pass through the filter, but in another experiment, where 4 c.c.s. of the same culture was diluted with 100 c.c.s., from the same bulk sample of Martin's broth, the resulting filtrate was sterile.

Summary.

The results of the experimental work carried out in order to obtain pure cultures of the organism for use in subsequent work can be summarised as follows:—

(1) Martin's broth (reaction + 10, Eyre's scale), with the addition of 7.5 per cent. of normal ox serum, is the best medium to employ in order to obtain primary cultures of the organism of contagious pleuro-pneumonia. Growth takes place under aerobic conditions of cultivation. The optimum incubation temperature is 37°C.

(2) Good growths can be obtained on subculture into Martin's broth, with the addition of either 7.5 per cent. normal ox serum, or normal horse serum, or normal rabbit serum. The most copious growth on subculture is obtained in Martin's broth plus horse serum, while Martin's broth plus rabbit's serum gives a more copious growth than Martin's broth plus ox serum.

(3) Following primary inoculation of Martin's broth plus ox serum media with virulent serosity, cultures can be obtained after 3 to 4 days' incubation at 37°C.; whereas the same sample of virulent serosity diluted and filtered through a Chamberland F. filter does not give a recognisable growth until approximately 21 days of incubation at 37°C. have elapsed.

(4) The organisms in cultures obtained from primary inoculation of virulent serosity into Martin's broth plus ox serum are capable of filtration through a Chamberland F. filter candle, provided that the culture is first diluted with Martin's broth (without serum) in the proper quantity, i.e., preferably about 1 per cent., but never exceeding 2 per cent. The growth obtained is only recognisable after approximately 21 days following the filtration and incubation of the filtrate at 37°C.

(5) The presence of a growth of the organism in Martin's broth serum media is apparent by the slight opalescence produced in the media after inoculation at 37°C. In order to recognise this opalescence it is imperative that uninoculated tubes of the same broth be incubated along with the inoculated ones. That this opalescence is produced by the growth of a micro-organism can be established by subcultures into other Martin's broth tubes and on to Martin's broth agar, and by the fact that in glucose and maltose Martin's broth media, with the appearance of the opalescence, the reaction of the media is rendered distinctly acid, whereas no change is apparent in Martin's broth, containing sac-

charose or lactose. Animal inoculation ultimately establishes the character of the organisms growing in the media.

Serological Tests.

In order to obtain a supply of cattle serum for subsequent tests, blood was obtained in sterile bottles from naturally infected animals which were slaughtered at the City and various Metropolitan Abattoirs. In each case the carcase of the animal supplying the blood sample was submitted to a post-mortem examination, and lesions of contagious pleuro-pneumonia were demonstrated in the lungs before the blood sample was labelled "positive." Each sample was given a number, and a record kept of the source of each sample

In addition to these samples, which were mainly collected by myself, I am indebted to the officers of the Stock Diseases Branch of the Victorian Department of Agriculture for several blood samples taken from animals which were killed in the field. No sample was labelled "positive" unless at the time the sample was taken the animal was submitted to a post-mortem examination, and found to be affected with recognisable lesions of pleuro-pneumonia. In this manner it has been possible to obtain a large and representative collection of positive blood samples from several individual outbreaks of pleuro-pneumonia in Victoria

Blood samples were also taken from cattle whose previous history could be definitely determined, and who were known not to be affected with pleuro-pneumonia, or to have been in contact with affected animals at any time prior to the taking of the blood sample. In addition to these "positive" and "negative" blood samples, blood samples were taken from a few animals which had reacted to an inoculation in the tail of virulent serosity taken from the lungs of an infected animal. These inoculated animals were found on slaughter and post-mortem examination not to be affected with any visible lesions of pleuro-pneumonia in the lungs. Samples of blood were taken from time to time from animals which were being kept and used at the Veterinary Research Institute as experimental animals for pleuro-pneumonia and other cattle diseases. In all cases the blood was taken from the jugular vein, and collected into sterile bottles. The blood was allowed to clot, and the serum to separate off from the clot. The serum was then decanted into another sterile bottle, and diluted in equal parts with 1 per cent. carbolic acid in normal saline solu-

tion Samples of serum were then kept in the ice-chest for use as required For use they were further diluted, if necessary, with saline solution immediately prior to being used in the tests until the required dilution was obtained A complete list of the serum samples obtained is as follows —

Serum Sample No	Source	Positive or Negative
1	Natural Infection	Positive
2	Natural Infection	Positive
3	Natural Infection	Positive
4	Natural Infection	Positive
5	Natural Infection	Positive
6	Natural Infection	Positive
7	Institute Cow No 36	Negative
8	Natural Infection	Positive
9	Direct contact with infected animals	Inoculated with virus in the tail and reacted No C P P on P M
10	Direct contact with infected animals	Inoculated with virus in the tail and reacted No C P P on P M
11	Natural Infection	Positive
12	Natural Infection	Positive
13	Natural Infection	Positive
14	Natural Infection	Positive
15	Natural Infection	Positive
16	Natural Infection	Positive
17	Experimental Cow No 2 (before inoculation)	Negative
18	Natural Infection	Positive
19	Institute Cow No 37	Negative
20	Direct contact with infected animals	Inoculated with virus in tail and reacted No C P P on P M
21	Direct contact with infected animals	Inoculated with virus in tail and reacted No C P P on P M
22	Direct contact with infected animals	Inoculated with virus in tail and reacted No C P P on P M
23	Natural Infection	Positive
24	Natural Infection	Positive
25	Natural Infection	Positive
26	Natural Infection	Positive
27	Natural Infection	Positive
28	Natural Infection	Positive
29	Experimental Cow No 4	Reacted to inoculation behind shoulder
30	Calf No 1	Immunised by an inoculation in the tail followed by inoculations behind the shoulder
31	Institute Cow No 35	Negative
32	Calf No 2	Immunised by an injection in the tail, followed by inoculations behind the shoulder

Agglutination.

Macroscopic Method.

For the purposes of an agglutination test a culture (second sub-culture 20 days old) of the organism in Martin's broth plus 7.5 per cent ox serum was taken and tested with known positive and negative sera, Nos 8 and 7 respectively. The ingredients were mixed in small agglutination tubes in the following proportions, and placed in the incubator at 37°C for 24 hours when the result was read

POSITIVE SERUM, No 8.

Tube	Culture (undiluted).	Serum (1 in 1)	Carbol* saline	Result
	c c	c c	c c	
1	1	1	1	—
2	1	0 75	1·25	—
3	1	0 5	1 5	—
4	1	0 25	1 75	—
5	1	0 1	1 9	—
6	1	0 06	1 94	—
7	1	0 04	1 96	—
8	1		2	—
9	—	1	2	—
10	1	—	—	—

NEGATIVE SERUM, No 7

Tube	Culture (undiluted).	Serum (1 in 1)	Carbol* saline	Result
	c c	c c	c c	
1	1	1	1	—
2	1	0 75	1 25	—
3	1	0 5	1 5	—
4	1	0 25	1 75	—
5	1	0 1	1 9	—
6	1	0 06	1 94	—
7	1	0 04	1 96	—
8	1	—	2	—
9	—	1	2	—
10	1	—	—	—

No agglutination was perceptible in any tube of either series, when the result was read after 24 hours' incubation at 37°C. The tubes were allowed to stand at room temperature for a further period of 16 hours, and were again examined, but no different result was obtained at this second reading.

In the conduct of these agglutination tests, those cultures were selected which showed a maximum amount of opalescence. It

* 0 5% carbolic acid in normal saline solution

should be noted, however, that the opalescence present in any of the cultures was extremely slight, and after the addition of serum and saline to the culture in the test, it was practically impossible to recognise any opalescence at all. In consequence of that fact, there was very little basis for comparing one tube with another, in order to note whether there had been any clearing of the fluid in the tubes.

Even if complete agglutination of all the organisms present in any tube were to take place, it is certain that the resulting deposit of agglutinated micro-organisms would be very slight indeed, and it is possible that it might not be easily recognisable as a deposit, particularly when no information can be obtained from an examination of the fluid for clearing.

An agglutination test was again set up, using as test sera Nos. 3 (positive) and 17 (negative). An alteration was made in the total quantity of the ingredients in the series of tubes, 1.5 c.c.s. of culture being taken as the standard amount of culture for each tube. The other ingredients were added to each tube in their proper quantities, viz., the quantities used in the first test. These tubes were also placed in the incubator at 37°C. for 24 hours, then examined, and then allowed to stand at room temperature for a further period of 16 hours, and again examined. There was no recognisable agglutination in any tube in either series, and altogether the result was exactly similar to that obtained with the test of sera Nos. 7 and 8

Simultaneously with the test of sera Nos. 3 and 17, another test was set up, the sera used being Nos. 30 and 17. Serum No. 30 was obtained from Calf 1, an experimental animal used at the Veterinary Research Institute, and one which had reacted to a subcutaneous inoculation in the tail of virulent serosity, taken from the lungs of an active case of pleuro-pneumonia. This calf had subsequently received a subcutaneous inoculation of 5 c c s of virulent serosity behind the shoulder without any extensive swelling being produced. Later, it had received 15 c.c s. of an 8 days' old pure culture of the organism in Martin's broth ox serum subcutaneously behind the other shoulder without any swelling or tissue change being produced at the site of inoculation. It was therefore assumed that Calf 1 had acquired a considerable degree of immunity against the inoculation of virulent pleuro-pneumonic material. For the test with this serum a second subculture 22 days old, in Martin's broth ox serum was

used as the test culture The result of the agglutination test with this serum was as follows:—

SERUM No 30

Tube	Culture (undiluted).	Serum (diluted) (1 in 1).	Carbol Saline	Result at 24 hours.	Result at 40 hours
	c c	c c	c c		
1	1 5	1 0	1 0	+	+ +
2	,,	0·75	1 25	+	+ +
3	,,	0 5	1 5	?	+
4	,,	0 25	1 75	—	?
5	,,	0 1	1 9	—	—
6	,,	0 06	1 94	—	—
7	,,	0 04	1·96	—	—
8	,,	—	2	—	—
9	—	1	2 5	—	—
10	1 5	—	—	—	—

SERUM No 17

Tube	Culture (undiluted).	Serum (diluted) (1 in 1).	Carbol Saline	Result at 24 hours.	Result at 40 hours
	c c	c c	c c		
1	1 5	1	1	—	—
2	,,	0 75	0 25	—	–
3	,,	0 5	1 5	—	—
4	,,	0 25	1 75	–	—
5	,,	0 1	1 9	—	—
6	,,	0 06	1 94	—	—
7	,,	0 04	1 96	—	—
8	,,	—	2	—	
9	—	1	2 5	—	—

+ + = Agglutination and sedimentation — = Negative reaction
+ = Recognisable agglutination ? = Doubtful reaction

In tubes 1 and 2 in the Serum-No -30 series, agglutination was perceptible after 24 hours' incubation at 37°C The amount of deposit in either tube was very small but it could be clearly recognised Tube 3, after 24 hours' incubation, appeared to show some agglutination, but it was so indefinite it could not be recorded as a "positive" result When read after standing at room temperature for a further period of 16 hours, tube 3 showed agglutination, while tube 4 showed an indefinite agglutination similar to tube 3 at 24 hours Tubes 1 and 2, after standing at room temperature showed agglutination and sedimentation, which was very clearly recognisable The reactions with Serum No 17 were negative throughout, while all the controls were negative also.

Having obtained a positive agglutination reaction with the serum of an animal which had been experimentally inoculated, the

question naturally arises: How can the failures to secure positive reactions with the sera from animals which are naturally affected with the disease be explained? It is conceivable, of course, that the amount of antibody (agglutinin) substance present in the blood serum of a naturally infected animal falls far short of the amount which is produced in an experimental animal as the result of several subcutaneous injections of virulent serosity and culture, and that, while with the latter serum agglutination can be observed as a macroscopic reaction, with the serum of a naturally infected animal agglutination may be only partially complete, and may not be recognisable macroscopically, if it takes place at all.

An important point which must not be overlooked is the method adopted in the immunisation of Experimental Calf 1. This animal was injected subcutaneously with virulent serosity, and subsequently with virulent serosity, and later with pure culture in Martin's broth ox serum.

The serum of an animal immunised in such a manner might possibly contain specific precipitins for ox serum, in which case turbidity in the reaction obtained with the serum of Calf 1, when tested for agglutinins, may have been due to some precipitin element, at least in part.

Zinsser (1914) (21), in discussing the specificity of precipitins and the precipitin reaction, refers to the experiments of Uhlenhuth, who "obtained a specific anti-hare serum by treating rabbit's blood with hare's blood—an astonishing result, in view of the close zoological relations between these animals Isoprecipitins, that is, precipitins resulting from the treatment of animals with blood from another individual of the same species, have also been described by Schutze and others They are not, however, regular in their appearance, nor are they very potent when obtained."[11]

It is very improbable, therefore, that an isoprecipitin would be formed in the blood of Calf 1, as a result of the immunising injections of virulent serosity and culture in Martin's broth, each of which injections contained a small amount of ox serum. Even assuming that an isoprecipitin was present, it scarcely seems possible that the serum of Calf 1 could produce by a precipitin reaction alone, such a definite deposit as that which occurred in the agglutination test already referred to.

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Microscopic Method.

In order to test whether the usual microscopic method of observing the agglutination reaction could furnish any additional evidence over the macroscopic method, two hanging-drop preparations were made under cover slips on hollow glass slides, the cover slips being ringed round with vaseline in order to prevent evaporation of the hanging drops. One hanging drop consisted only of pure culture of the organism in Martin's broth plus ox serum, and on microscopic examination showed no trace of any recognisable micro-organisms when using the highest magnification available (1000 diameters). The other hanging drop consisted of a mixture of the same culture, and a positive serum in the proportion of 2 parts of culture to 1 part of serum dilution, serum No. 12 being used. This preparation was examined microscopically at various intervals extending over 4 hours, but at no time could any alteration in the appearance of the hanging drop be observed. No difference in appearance under the microscope could be noted when the hanging drop containing culture and serum was compared with that containing culture only.

In order to have a further means of comparison it was decided to repeat this hanging drop test, and to control it more efficiently, two additional hanging drop preparations were put up Thus we had for examination four hanging drop preparations containing the following ingredients respectively:—

Hanging-Drop Preparation No. 1, containing culture only.

Hanging-Drop Preparation No 2, containing culture (2 parts), and serum dilution (1 part); the serum being Serum No 12 (positive serum).

Hanging-Drop Preparation No. 3, containing culture (2 parts), and serum dilution (1 part); the serum being Serum No. 30.

Hanging-Drop Preparation No 4, containing culture (2 parts), and serum dilution (1 part); the serum being No 17 (negative serum).

Serum No 30 was the serum from Experimental Calf 1, which had previously given a positive agglutination reaction when tested by the macroscopic method

Serum No 17 was a negative serum, and had previously given a negative agglutination reaction when tested by the macroscopic method. The preparations were examined microscopically at

intervals extending over 5 hours, during which time no alteration was apparent in any of the preparations. Even in Preparation No. 3, which contained Serum No. 30, no agglutination could be recognised under the microscope.

Agglutination Experiments with Concentrated Culture.

In conducting the macroscopic agglutination test it had been found that the dilution of culture brought about by the addition of test serum made it impossible to recognise any opalescence in the fluid in the tubes It was therefore considered advisable to attempt to produce a concentration of the culture so that the opalescence would be more distinct, and would be clearly visible when the other ingredients of the test were added. Culture in Martin's broth ox serum was placed in centrifuge tubes and whirled in an electric centrifuge at the highest speed the machine was capable of attaining (2500 revolutions per minute) for 4½ hours. At the end of that time the tubes were examined, but it was found that it was not possible to effect concentration of micro-organisms in that manner, because the opalescent particles (organisms) in the broth were so fine and light they could not be thrown down to the bottom of the tubes.

An attempt was then made to concentrate culture by the evaporation of some of the fluid medium in which the culture was growing This evaporation was first tried at room temperature by placing a quantity of culture in a flat dish (Petri dish) inside a desiccator, provided with a circular trough, which contained pure sulphuric acid. Inside the desiccator a more or less complete vacuum was established and maintained. It was found that with such an apparatus, the rate of evaporation at room temperature was too slow, so the apparatus was placed in the incubator and evaporation attempted at incubator temperature At incubator temperature, and with the joints of the desiccator sealed with "plasticine" (the temperature made it impossible to use vaseline for the purpose), there was difficulty in maintaining the vacuum, and, altogether, the experiment was not a success. It was then decided to attempt the evaporation of culture at room temperature by using a method, of which the following is a description:—

424 c.c. of culture in Martin's broth plus ox serum was placed in a flask (Flask A), furnished with a side-arm, and the mouth of the flask was firmly closed with a tightly fitting solid rubber

stopper. A length of india-rubber pressure tubing was attached to the side arm of Flask A, the other end of the tubing being attached to the side arm of Flask B. Flask B was empty, and was closed at the mouth by an india-rubber stopper, which was perforated to give passage to a length of glass tubing, one end of which extended to the bottom of Flask B. On the other end of this glass tube another piece of india-rubber pressure tubing was attached, and was connected to a piece of glass tubing perforating the india-rubber stopper of Flask C, which was a flask exactly similar to Flask B. A piece of india-rubber pressure tubing connected Flask C by the side arm to the glass tubing perforating the cork of a Sulphuric Acid Tower (D). The sulphuric acid tower was connected by rubber tubing to an aspirator. (A Korting pattern water pump.) This aspirator maintained a negative pressure in Flasks A, B, C, and in the tower D. Flask A, containing the culture was kept at room temperature. Flask B was placed in a receptacle containing crushed ice and salt, the flask being quite covered by the freezing mixture Additional ice and salt were added from time to time as required. The fluid, which collected in Flask B, was transferred to Flask C by aspiration. At the end of 24 hours the apparatus was dismantled, and the contents of Flask A were measured, and were found to be only 173 c.c.s.; 251 c.c.s. of clear watery solution having passed over into Flasks B and C. This 173 c.c.s. of concentrated culture showed a very marked turbidity, and a quantity of it was used as an antigen (Antigen J) in the complement fixation test, and a further quantity was used for agglutination tests as follows:—

First Test.

Concentrated culture with Serum No. 26 (positive), and Serum No. 7 (negative).

SERUM No. 26 (POSITIVE)

Tube	Culture (concentrated). c.c.	Serum (diluted 1 in 1). c.c.	Carbol Saline c.c.	Result at 24 hours.	Result at 48 hours.
1	1·5	1	1	—	—
2	,,	0·75	1·25	—	—
3	,,	0·5	1·5	—	—
4	,,	0·25	1·75	—	—
5	,,	0·1	1·9	—	—
6	,,	0·06	1·94	—	—
7	,,	0·04	1·96	—	—
8	,,	—	2	—	—
9	—	1	2.5	—	—
10	1·5	—	—	—	—

SERUM No. 7 (NEGATIVE)

	c c	c c	c c		
1	1·5	1	1	—	—
2	"	0·75	1·25	—	—
3	"	0·5	1·5	—	—
4	"	0·25	1·75	—	—
5	"	0·1	1·9	—	—
6	"	0·06	1·94	—	—
7	"	0·04	1·96		—
8	"	—	2	—	—
9	—	1	2·5	—	—
10	1·5	—	—	—	—

— = Negative reaction

Second Test

Concentrated culture with Serum No 23 (positive), and Serum No 31 (negative)

This test was set up in exactly the same manner as the preceding test (Test 1), and the result obtained was exactly similar to that obtained with Test 1

Third Test.

Concentrated culture with Serum No 30 (from Experimental Calf 1), and Serum No 31 (negative).

SERUM No 30 (POSITIVE)

Tube	Culture (concentrated)	Serum (diluted 1 in 1)	Carbol Saline	Result at 24 hours	Result at 40 hours
	c c	c c	c c		
1	1·5	1	1	+ +	+ +
2	1·5	0·75	1·25	+ +	+ +
3	"	0·5	1·5	+ +	+ +
4	"	0·25	1·75	+	+
5	"	0·1	1·9	+	+
6	"	0·06	1·94	?	?
7	"	0·04	1·96	—	—
8	"	—	2	—	—
9	—	1	2·5	—	—
10	1·5	—	—	—	—

SERUM No 31 (NEGATIVE)

	c c	c c	c c		
1	1·5	1	1	—	—
2	"	0·75	1·25	—	—
3	"	0·5	1·5	—	—
4	"	0·25	1·75	—	—
5	"	0·1	1·9	—	—
6	"	0·06	1·94	—	—
7	"	0·01	1·96	—	—
8	"	—	2	—	—
9	—	1	2·5	—	—
10	1·5	—	—	—	—

++ = Agglutination and sedimentation — = Negative reaction
+ = Agglutination ? = Doubtful Reaction

The marked turbidity of the concentrated culture made it possible to still recognise some turbidity in the tubes when the necessary amounts of serum and saline were added, so that, in these tests with concentrated culture, it was possible to compare the fluid in the tubes for any clearing which might take place during the test. Excepting with the tubes containing Serum No. 30, no clearing of the test fluid occured, and no agglutination could be demonstrated when serum from a naturally infected animal was mixed with a culture of the filter passing organism isolated from a case of contagious pleuro-pneumonia.

The failure to obtain a recognisable agglutination reaction with this concentrated culture when mixed with the sera of naturally infected animals made us abandon the agglutination test as a potential diagnostic reaction for the detection of contagious pleuro-pneumonia in the living animal.

Ability of the Organism to Grow in Media containing Immune Sera.

On the conclusion of these aggultihation tests it was decided to try if the addition to the culture medium of serum from naturally infected and from experimentally inoculated animals would influence the growth of the organisms when subcultures were made into such media. For this experiment, three separate batches of media were prepared. The first consisted of Martin's Peptone Broth plus 7.5 per cent of Serum No. 27, which was obtained from a naturally infected animal The second consisted of Martin's Peptone Broth, plus 7.5 per cent. of serum No. 30, which was obtained from Experimental Calf 1. The third consisted of Martin's Peptone Broth plus 7.5 per cent. of normal ox serum.

Several tubes of each batch of medium were inoculated from a primary culture of the organism in Martin's broth plus normal ox serum. Growths took place in all the tubes inoculated. In the tubes containing Serum No. 27 (from a naturally infected animal) the characteristic opalescence was observed four days after inoculation and incubation at 37°C., and on comparison with the tubes of Martin's broth, plus normal ox serum, inoculated at the same time from the same source, no difference in the degree of opalescence, or in the general appearance of the cultures could be observed. On comparing the cultures containing the serum from Experimental Calf 1 with those containing Serum No. 27,

it was distinctly noticeable that in the former tubes the characteristic opalescence was more marked, but there was no recognisable sedimentation at the bottom of the culture tubes. It is not considered that the increased opalescence in the cultures growing in the media containing the serum of Experimental Calf I was produced by a more vigorous growth of the organisms in those tubes, but in all probability it was due to a partial agglutination of the organisms in the culture fluid, and the interception of rays of light in their passage through the culture fluid by the slight agglomerations of partly agglutinated organisms floating in the culture media. The experiment was adequately controlled by incubating at the same time tubes of the same media which had not been inoculated with the primary culture. These control tubes maintained an unaltered appearance throughout

Complement Fixation.

To test the complement fixation reaction in contagious pleuro-pneumonia, the following ingredients for the test were prepared as required.

(1) Haemolytic Amboceptor.—The serum of a rabbit immunised by repeated injections of the washed red blood corpuscles of a sheep. This rabbit's serum was inactivated by heating in a water bath at 56°C. for 30 minutes, and for the tests was employed in a dilution of 1 in 1000 with saline solution. The exact dilution and the amount for the test was established at the commencement of the test by one or more titration experiments. The titre of this Haemolytic Amboceptor was never less than 1 in 1000 when used in any of the complement fixation tests.

(2) Corpuscle Suspension.—A 5 per cent. suspension in saline solution of the washed red blood cells of a sheep.

(3) Complement.—Fresh guinea-pig's serum, diluted 1 in 10 with saline solution, the minimum haemolytic dose (M.H.D.) being established by titration.

(4) Saline Solution.—0.9 per cent. sodium chloride solution, filtered, and sterilised.

(5) Test Sera.—Obtained from Bovines.

In the earlier complement fixation tests, which were carried on over a period of several months, the test sera were diluted with equal parts of 1 per cent. carbolic acid in saline solution for preservation, and were kept in the ice chest for use as required. They were further diluted with physiological saline solu-

tion immediately prior to use in the tests. Although the quantity of carbolic acid present in the amount of serum dilution used in the tests was infinitesimal, it was considered that better results might be obtained if the carbolic acid was eliminated altogether. It was therefore decided to inactivate the bovine sera at 56°C. for half an hour on two consecutive days as soon as possible after collection, and store them in the ice chest in an undiluted form for use as required. It has been found that sera so treated invariably remain clear and sterile.

Tests made with two quantities of serum from the one animal, one quantity of which was only once heated at 56°C. for half an hour, the other quantity being heated at 56°C. for half an hour on two consecutive days, showed no difference in their complement fixing properties. The double heating is advisable if the sera are to be preserved for any length of time.

(6) Antigen.—Cultures in Martin's broth plus ox serum or horse serum were used as Antigens, but before use were prepared as follows:—The culture was heated in a water bath at 56°C. for one hour, then diluted in equal parts with 1 per cent. carbol saline solution The mixture was then placed in a mechanical shaking apparatus, and thoroughly shaken for 5 hours. It was then placed in the ice chest for 24 hours, and before use in the test was further diluted by using 1 part of culture mixture to 4 parts of 0.9 per cent. saline solution, forming a 1 in 10 dilution of the original culture.

With the exception of "Antigen A," all the culture preparations used from time to time as antigens in the complement fixation tests were prepared in the above manner. The various cultures prepared and tested as antigens are enumerated in the following table:—

Antigen A—A fourth subculture of the filter-passing organism in Martin's broth ox serum. It was first used on 18/11/19, after 8 days of growth, in a 1 in 10 dilution with saline solution. It was anticomplementary when any quantity in excess of 0.1 c.c. of a 1 in 10 dilution was used. On 24/11/19, it was not anticomplementary when used in an amount of 0.25 c.c. of a 1 in 10 dilution. On 11/12/19 (after 30 days of growth) it showed anticomplementary action in quantities of 0.1 c.c. of a 1 in 10 dilution in saline.

Antigen B.—A first subculture, 12 days old, in Martin's broth ox serum. Not anticomplementary in doses of 0.25 c.c. of a 1 in 10 dilution.

Antigen C.—A third subculture, 14 days old, in Martin's broth-horse serum. (Primary culture in Martin's broth ox serum, first and second subcultures in Martin's broth horse serum.) It was markedly anticomplementary in quantities of 0.25 c.c. of a 1 in 10 dilution, but gave no inhibition of haemolysis in quantities of 0.15 c.c. of a 1 in 10 dilution.

Antigen D.—A divalent antigen. A mixture of a third subculture 8 days old, and a second subculture 10 days old, from two separate sources. Both cultures were grown in Martin's broth plus ox serum. Not anticomplementary in quantities of 0.25 c.c. of a 1 in 10 dilution.

Antigen E.—A 28 days old culture (filtration experiment) in Martin's broth ox serum. Not anticomplementary in quantities of 0.2 c.c. of a 1 in 10 dilution. Slight inhibition with 0.25 c.c. of the same dilution.

Antigen F.—Lung serosity from an active case of contagious pleuro-pneumonia. Very anticomplementary in all quantities of a 1 in 10 dilution. 0.5 c c. of a 1 in 20 dilution in saline showed no inhibition of haemolysis.

Antigen G.—Oedematous fluid from the zone of inoculation behind shoulder (Experimental Cow 4), taken 16 days after inoculation. Not anticomplementary in quantities of 0.3 c.c. of a 1 in 10 dilution.

Antigen H.—A polyvalent antigen made up of four strains of culture in Martin's broth ox serum. (One culture 8 days old; one culture 14 days old; one culture 16 days old; and one culture 21 days old). Culture mixture not anticomplementary in quantities of 0.25 c.c. of a 1 in 10 dilution.

Antigen J.—Concentrated culture in Martin's broth plus ox serum, concentrated by evaporation (*vide supra*).

Complement Fixation Tests with Pure Culture.

These various culture preparations were tested for complement fixation with known positive and negative sera. A number of tests were conducted with each antigen preparation, but in every case the test showed that the antigen plus positive serum combination did not fix complement; the final result in all such cases being complete haemolysis Antigen plus negative serum gave complete haemolysis also; thus, complete haemolysis took place irrespective of whether the serum used was obtained from a positive or negative source.

Serum No. 30 from Experimental Calf 1 (the animal whose serum had previously given a positive agglutination reaction when tested by the macroscopic method) was tested with various culture preparations including Antigen J. There was no fixation of complement in any combination tested, and the haemolysis was just as complete in the positive serum series as it was in the negative serum series put up at the same time.

Culture preparations (antigens) obtained by the cultivation of virulent serosity from the lungs of the animal supplying positive Serum No. 28, were tested with this latter serum for complement fixation. It was found that, in each instance, the reactions were negative.

Various other tests were carried out with culture preparations which it is unnecessary to enumerate. Suffice it to say that in no case, using culture as an antigen, was a positive complement fixation result obtained.

Discussion.

At this stage it was decided to review that portion of the work relating to complement fixation, in an endeavour to ascertain the reason why, in the tests carried out, it had been impossible to obtain complement fixation with a known positive serum.

It is conceivable, of course, that filterable viruses in general do not behave in the same way as bacteria, i.e., they may not react to the usual serological tests that bacteria react to. This idea is strengthened by the fact that, although the usual serological reactions have been tested with a number of other filterable viruses, as well as with contagious pleuro-pneumonia by several experienced workers, the results obtained have either been negative, or else so contradictory that it has been impossible to elaborate a test, using the ordinary technique of such serological reactions, which could be used with certainty for diagnostic purposes. On the other hand it is possible that certain serological reactions can be obtained, provided a special technique is employed, either in the preparation of the component parts of the test, or in the method of conducting the test, or both.

Antigens.

The first question which presented itself on reviewing the earlier complement fixation experiments was: Were the antigens used in those experiments strong enough in a specific sense to bring about complement fixation? It will have been noted

that when antigens consisting of pure cultures of the organism of contagious pleuro-pneumonia in Martin's broth were used, complement fixation did not occur.

These results were capable of one of two interpretations:—

(1) That culture was unsuitable for antigenic purposes;

(2) That complement fixing antibodies were not present in the serum of animals affected with contagious pleuro-pneumonia.

The first interpretation was temporarily accepted as the more probable. The second could not be accepted without further evidence; so, in order to determine whether complement fixing antibodies were or were not present in the serum of animals affected with contagious pleuro-pneumonia, tissue extracts were next prepared and tested as antigens.

The first tissue extracts prepared were saline extracts of diseased lung tissue, taken from animals showing active and extensive lesions of contagious pleuro-pneumonia on post-mortem examination. These saline extracts of diseased lung tissue were prepared as follows:—

Carefully selected diseased lung tissue was cut into small pieces and ground up in a mortar with a little sterile sea sand. Four times its weight of carbol saline solution was added, and the mixture placed in a tightly stoppered bottle, and shaken for five hours in a mechanical shaking apparatus. The mixture was then filtered through gauze to remove all the coarser particles of the tissue. It was then placed in the ice chest for a week, to allow sedimentation to take place, after which time the supernatent fluid was carefully pipetted off without disturbing the deposit. The supernatent fluid—which is yellowish-brown in colour, and slightly opalescent—was then diluted 1 part in 10 with 0.9 per cent. saline solution, and was used in that dilution in the test, after titration to determine the anticomplementary unit.

These saline extracts were thoroughly tested with a number of known positive and known negative sera, but in no instance was a positive fixation result obtained.

A saline extract of the sub-epidermal tumour tissue removed from the inflammatory tumour, which had developed behind the shoulder of an experimentally inoculated animal (Experimental Cow 4) was next prepared. This tissue was not regarded as entirely satisfactory for test purposes, for, at the time of its removal, the tissue was showing marked evidence of necrosis. The method adopted in the preparation of this tissue extract differed

slightly from the method employed for the preparation of the saline extracts of lung tissue and was as follows —10 grams of the inflamed subepidermal tumour tissue was cut into small pieces and ground up in a mortar with a little sterile sea sand. 40 c c s of 0 5 per cent carbolic acid in 0 9 per cent saline solution was then added and the mixture placed in a tightly stoppered bottle and shaken in a mechanical shaker for five hours It was then filtered through gauze to remove the coarser particles and then placed in the ice chest for a week being shaken up occasionally It was finally allowed to sediment and the supernatent fluid decanted This fluid was filtered through filter paper and again placed in the ice chest for a further 48 hours The supernatent fluid was then carefully pipetted off without disturbing the slight deposit in the bottle 1 c c of this fluid was then diluted with 9 c c s of 0 9 per cent saline solution and was titrated to determine the anticomplementary unit This 1 in 10 dilution was used in the test

When tested with positive sera Nos 11 and 25 this saline extract gave a negative reaction but when tested with Serum No 30 (from Experimental Calf 1) a positive complement fixation was recorded This was the first positive complement fixation result recorded although Serum No 30 had been tested with practically every antigen preparation which had been previously tried

It should be pointed out that Experimental Calf No 1 had been specially immunised by several subcutaneous inoculations of virulent material therefore the serum of Calf 1 would be expected to be highly specific and not properly comparable with the serum of an animal affected with the disease naturally acquired

As extracts of sub epidermal tumour tissue apparently offered the most favourable chances of obtaining a successfully reacting antigen a number of saline extracts were prepared from sub epidermal tumour tissue taken from behind the shoulder of Experimental Cow 6 (who was destroyed owing to the extensive infiltrating oedema which had developed as a result of the inoculation of pure virus behind the shoulder and from which the animal was dying) This extract gave a strongly positive result when tested with Serum No 30 and gave some fixation with positive sera Nos 33 36 37 and 39 but with positive sera Nos 34 35 35a 35b and 38 the results were negative haemolysis taking place in the antigen containing tubes just as readily as in the serum control tubes which did not contain antigen

Alcoholic Extracts of Diseased Tissue used as Antigen.

Saline extracts of diseased tissue having proved unsatisfactory for antigen purposes, alcoholic extracts were next prepared and tested. Thin slices of inflamed sub-epidermal tumour tissue taken from Cow 6, when the animal was destroyed, had been dried in the incubator at 37°C. for some days, and preserved in the dry state in a closely stoppered bottle. Of this dried tissue, 5 grams were taken, and finely pulverised in a mortar with the addition of a small quantity of powdered glass. 50 c.c.s. of alcohol were then added, the whole placed in a tightly stoppered bottle, and placed in a mechanical shaking apparatus and thoroughly shaken for 12 hours. It was then stored in the ice chest for 12 days, being shaken up at least once a day. The fluid was then poured off into centrifuge tubes, and whirled in the centrifuge. The supernatent fluid was then carefully pipetted off without disturbing the deposit. 1 c.c. of this alcoholic extract was diluted with 9 c.c.s. of 0.9 per cent. saline solution, the dilution being made slowly in order to obtain the maximum amount of turbidity. This antigen dilution was then titrated in order to ascertain its anticomplementary and complementary units.

An important point of technique in the preparation of this antigen for test purposes is the method of diluting the alcoholic extract with saline solution.

If the alcoholic extract and saline solution are mixed quickly a slightly turbid mixture results which gives only slight fixation when tested with known positive sera. On the other hand, when the alcoholic extract and saline solution are mixed slowly, an extremely turbid mixture is obtained, the amount of turbidity being in direct proportion to the time allowed for mixing. The mixtures possessing the maximum amount of turbidity have been found on testing to give the maximum amount of fixation.

The alcoholic extract of sub-epidermal tumour tissue was tested with a number of known positive and known negative sera, and after having been tested with 24 different sera, it was found that the test result in each case was in agreement with the post-mortem findings when the animals supplying the test sera were slaughtered and examined.

Thus it is evident that complement fixing antibodies are present in the sera of animals affected with contagious pleuro-pneumonia, and the complement fixation test provides us with a means of differentiating between infected and non-infected animals.

Conglutinin.

It was found, when carrying out tests with the alcoholic extract of sub-epidermal tumour tissue, that, while complement fixation occurred with known positive sera, the reaction was liable to become masked by a subsequent haemolysis of the sensitised red blood cells added as an indicator.

Different positive sera exhibited this tendency to bring about final haemolysis in varying degrees—i.e., some were more prone to it than others—but as haemolysis invariably occurred, it was evident that there was contained in the test serum some element which was capable of acting upon the sensitised red blood cells after fixation of complement had occurred. This haemolysis made it exceedingly difficult to differentiate between the reaction given by a known negative serum, and a known positive serum, because, in some cases, the length of time between the haemolysis with a negative serum, and the haemolysis with a positive serum was only a matter of a few minutes.

It was also noticed that in the final test, on the addition of the sensitised red blood cells, the red blood cells were almost immediately "agglutinated" and sedimented more or less completely at the bottom of the tubes.

It was thought at first that this "agglutination" of red blood cells could be made use of for diagnostic purposes, but it was very soon demonstrated that, while, as a general rule, the phenomenon occurred earliest in the tubes containing negative sera, certain of the tubes containing positive sera also showed early "agglutination," of the red blood cells.

On the other hand, some tubes containing negative sera showed a delayed "agglutination" of the red blood cells. A similar delayed "agglutination" was also shown in certain of the tubes containing positive sera.

It was thus evident that this phenomenon was of no diagnostic importance, because its appearance depended upon some substance which was present in all the bovine sera tested, although present in a varying amount. This substance was not more often present in negative sera than in positive sera, although, as a general rule, the reaction appeared earlier with negative sera.

Bordet and Gay (1906) (3) in studying the action of inactivated bovine serum upon sensitised corpuscles in the presence of complement, demonstrated the presence in bovine serum of a specific substance which they first referred to as "colloid sub-

stance," but which they afterwards termed "conglutinin." The name "conglutinin" was suggested by the action of this substance upon sensitised red blood cells, with a suitable complement. In such a combination the red blood cells were energetically "agglutinated" and sedimented. Although the reaction was similar to the action of a powerful agglutinin, it differed from the action of an agglutinin in that complement was a necessary ingredient in the combination for this phenomenon to occur. Complement is not necessary to complete the action of an agglutinin.

These authors found that this substance—conglutinin—present in varying amounts in bovine sera, was capable of exercising a remarkable influence upon the final result in a haemolytic test. In a series of experiments they demonstrated that the substance, acting in conjunction with a weak complement, could conglutinate and haemolyse sensitised red blood cells, although the amount of complement taking part in the reaction, by itself and without conglutinin, was incapable of producing haemolysis. In other words, it was demonstrated that conglutinin could combine with a weak complement, and the combination could then exert a powerful haemolytic action upon sensitised red blood cells.

In the technique of the complement fixation tests described in the previous chapter, the complement was titrated against one unit of sensitised red blood cell suspension, in order to determine the minimum haemolytic dose (M.H.D.) of complement. Against this standardised haemolytic system the other ingredients of the test were titrated, in order to ascertain the proper quantities of each to employ in the final stage of the test. When, however, in the final test, bovine serum and complement are mixed together, and incubated, and then sensitised red blood cells are added, the influence of conglutinin becomes exerted, and the previously titrated M.H.D. of complement apparently becomes more than the M.H.D. required for haemolysis, so that a fixation with a positive serum may still leave sufficient complement available to be reinforced by the conglutinin present, and produce haemolysis of the sensitised red blood cells.

In order to test this hypothesis, the following experiment was carried out:—

A series of tubes (Series A) was set up, and into each tube was measured decreasing quantities of fresh guinea-pig's serum (1 in 10 dilution), from 0.5 c.c. downwards. The fluid in all

the tubes was then brought to a common level by the addition of 0 9 per cent saline solution, so that each tube contained 2.5 c c of fluid One unit of sensitised red blood cells (sheep) was then added to each tube, and, after shaking, the tubes were placed in the incubator at 37°C Results were read at the end of half an hour, one hour, and two hours' incubation respectively, and, of the tubes showing complete haemolysis, the one containing the smallest amount of complement was noted From the table set out below it will be seen that this tube was tube 6, which contained 0 25 c c of complement dilution, that amount being the minimum quantity required to completely haemolyse one unit of sensitised red blood cells in one hour at 37°C Even after two hours' incubation it was found that no tube lower than tube 6 in the series showed complete haemolysis

Parallel with series A, series B was set up The quantities of sensitised red blood cells and complement dilution were exactly the same as those used in the corresponding tubes in series A, but to each tube in series B (excepting where indicated in the controls), 0 15 c c of a 1 in 10 dilution of inactivated bovine serum was added The tubes were filled to a common level with saline solution, as in series A, and placed in the incubator at 37°C, the results being read after half an hour, one hour, and two hours' incubation Each series was thoroughly controlled, as shown in the following tables —

SERIES A

Tube	Complement 1 in 10	Saline 0 9%	Sensitised R B C s.	Degree of Haemolysis after incubation for: Half hour	One hour	Two hours
1	5	2 0	5	Complete	Complete	Complete
2	45	2 05	5			,,
3	4	2 1	5		,,	,,
4	35	2 15	5	,,	,,	,,
5	3	2 2	5	,,	,,	,,
6	25	2 25	5	Almost complete	Complete	Complete
7	2	2 3	5	Partial	Partial	Not complete
8	15	2 35	5	Very slight	Slight	Slight
9	1	2 4	5	None	Very slight	Slight
10	05	2 45	5	None	None	None
11	—	2 5	5	None	None	None

SERIES B.

Tubes.	[illegible] 1 in 10	Complement 1 in 10	Saline, c.c.	Sensitised R.B.C. 5%	Degree of Haemolysis after incubation at 37°C for: Half hour.	One hour	Two hours.
1	·15	·5	1·85	·5	Complete	Complete	Complete
2	·15	·45	1·9	·5	"	"	"
3	·15	·4	1·95	·5	"	"	"
4	·15	·35	2·	·5	"	"	"
5	·15	·3	2·05	·5	"	"	"
6	·15	·25	2·1	·5	Partial	"	"
7	·15	·2	2·15	·5	Slight	"	"
8	·15	·15	2·2	·5	Slight	Partial	"
9	·15	·1	2·25	·5	Very slight	Slight	"
10	·15	·05	2·3	·5	None	Slight	Almost complete
11	·15	—	2·35	·5	None	None	None
12	—	—	2·5	·5	None	None	None

The results in series B, read after incubation for half an hour, were almost exactly similar to the haemolytic results obtained with series A, after incubation for half an hour. In series B, however, the sensitised red blood cells were energetically conglutinated shortly after they were added. After incubation for one hour, series B showed complete haemolysis in tubes 1 to 7, and varying degrees of haemolysis in tubes 8, 9, and 10. At the end of two hours' incubation haemolysis was complete in tubes 1 to 9, while in tube 10 haemolysis was almost complete.

It is thus evident that the influence of conglutinin upon a small amount of complement is such that in the complement fixation test for contagious pleuro-pneumonia, it enables haemolysis to occur with a smaller quantity of complement than the ordinarily titrated M.H.D.

If we critically examine the figures revealed by the foregoing experiment, it is at once apparent that the presence of conglutinin in the bovine test serum introduces a factor into the complement fixation test in contagious pleuro-pneumonia, which factor, if not properly controlled, would render the test absolutely unreliable for diagnostic purposes.

It has been shown in this experiment that it requires 0·25 c.c. of complement dilution to completely haemolyse one unit of sen-

sitised red blood cells. The M.H.D. of complement is thus 0.25 c.c. of a 1 in 10 dilution. If now we set up a test as follows:—

Antigen 1 in 10.	Inactivated Bovine serum, 1 in 10.	Complement 1 in 10.	Saline ·9%	Sensitised R.B.C. 5%.
c.c. ·15	c.c. ·15	c.c. ·25	Q.S. to make up to 2.5 c.c.	1 unit

and assume that the bovine serum being tested is a positive serum, we would find that complement would be fixed by the combination of antigen—positive serum; but—and this is the important point—apparently not all the complement is fixed. A certain amount of complement remains unfixed, because it appears that the combination of antigen and antibody in contagious pleuro-pneumonia is only capable of fixing a small amount of complement. The small amount of complement remaining unfixed is less than the M.H.D. required to produce haemolysis of the haemolytic system, but it is reinforced by the conglutinin present in the bovine serum, and thus reinforced, it conglutinates and ultimately haemolyses more or less completely the unit of sensitised red blood cells added to the test as an indicator.

In order to overcome errors due to this action of conglutinin upon a fraction of the M.H.D. of complement, the final reading of the complement fixation test in contagious pleuro-pneumonia has to be made in strict conjunction with an adequate number of control tubes. These will be fully considered later in the section, dealing with "Technique."

In this discussion upon the action of conglutinin, there is another point of some importance, which must be referred to briefly.

It is probable that conglutinin can bring about a conglutination reaction, in the presence of complement, with other antigen-antibody combinations besides the antigen-antibody combination contained in the haemolytic system. For instance, the conglutinin in the bovine serum may vary the reaction of our antigen and antibody (where a positive serum is being used, and especially where culture is used as antigen). If such is the case, the joining up of the antigen-antibody-complement combination in the first portion of the final test for complement fixation may be expected to be delayed considerably, but thereafter sufficient complement may remain free on the addition of the sensitised red blood cells to bring about haemolysis. If this is so, the frequency with which negative complement fixation reactions were obtained in our

earlier experiments with pure culture as antigen, and with sera obtained from known positive cases of contagious pleuro-pneumonia could be explained.

In concluding this section on conglutinin it is perhaps worthy of mention that amongst the many experiments carried out with conglutinin was an experiment to determine whether a modified conglutination reaction, possessed any diagnostic value in contagious pleuro-pneumonia. For this experiment, culture and a known positive serum were mixed together in graded doses, and allowed to remain in the incubator for 12 hours. At the end of that time complement was added to each tube. It was thought that the combination of culture (antigen) and positive serum (antibody) would be conglutinated by the combined action of conglutinin and complement.

Although encouraging results were obtained at first, it was soon demonstrated that this method was quite unreliable for diagnostic purposes.

Quantitative Relationship between Complement and Amboceptor in the Production of Haemolysis.

Morgenroth and Sachs (1902) (11) have demonstrated that within certain limits there exists an inverse relationship between haemolytic amboceptor and complement in the production of haemolysis. If for a given quantity of red blood cells a certain quantity of haemolytic amboceptor and complement is required to bring about complete haemolysis, reduction of either the complement or amboceptor necessitates an increase of the other factor.

Noguchi (1911) (14) has shown that in the presence of one unit of haemolytic amboceptor, 0.1 c.c. of guinea-pig's complement is required to produce complete haemolysis of a given quantity of red blood cells in a given time, while, by using 4, 8, and 20 units of amboceptor, complete haemolysis of a similar quantity of red blood cells is obtainable in the same time with 1/3, 1/5, and 1/10 of the 0.1 c.c. of complement respectively.

This inverse relationship between amboceptor and complement is of the utmost importance in complement fixation work in contagious pleuro-pneumonia, because it enables us to overcome the action of conglutinin to a certain extent.

If in the standardisation of the haemolytic system for complement fixation in contagious pleuro-pneumonia, the unit of com-

plement (M.H.D.) is ascertained by titrating the complement with red blood cells, sensitised by more than a single unit of amboceptor, it is possible to arrive at a unit of complement, which is just large enough to effect complete haemolysis of the sensitised red blood cells, in the case of a negative serum, but which at the same time is small enough to be more or less completely fixed by the antigen—antibody combination in the case of a positive serum.

This "overloading" of the haemolytic system with amboceptor cannot be increased beyond certain limits. While a slight increase of the amboceptor factor is a decided advantage, the increase must not exceed two complete units, for it has been found that, owing to the feeble nature of the fixation which occurs in contagious pleuro-pneumonia, a large increase in the amount of amboceptor in the haemolytic system tends to dissociate some of the complement already held by the antigen-positive serum combination. In consequence of this, a large excess of amboceptor only tends to shorten the time required for haemolysis to occur.

It has been found that the best results have been obtained by using 1½ units of amboceptor to sensitise the red blood cells, and then to titre the complement against one unit of these over sensitised cells, in order to determine the absolute M.H.D. of complement required for haemolysis

Technique of the Complement Fixation Test for Contagious Pleuro-Pneumonia.

The method of carrying out the test is as follows:—

0 5 c c of a 5 per cent. suspension of sheep's red blood cells equals 1 unit Against this unit, the haemolytic amboceptor is titrated, and it is found that 0 5 c c. of 1 in 1000 dilution equals one unit of haemolytic amboceptor. Each unit of red blood cells is sensitised by 1½ units of haemolytic amboceptor, by mixing together the necessary units of amboceptor and red blood cell suspension, and allowing them to stand for one hour. The mixture is then centrifuged, and the clear fluid pipetted off. The sensitised red blood cells are then washed with saline solution, and are resuspended in saline in order to make a 5 per cent. suspension. 0 5 c c. sensitised red blood cells (5 per cent. suspension) equals one unit.

The complement (guinea-pig's serum, 1 in 10), is now titrated against one unit of sensitised red blood cells, by testing it in

decreasing doses from 0.5 c.c. downwards. The smallest amount of complement necessary to produce complete haemolysis in 1/4 hour is noted. This amount varies in different complement samples, but is usually approximately 0.15 c.c. of a 1 in 10 dilution. The estimation of the minimum haemolytic dose (M.H.D.) of complement must be decided with absolute accuracy, any quantity in excess of the absolute M.H.D. being sufficient to render the reading of the final test exceeding difficult, if not impossible. The necessity for only adding the absolute M.H.D. of complement to the final test, will be obvious when the action of conglutinin is considered.

When the M.H.D. of complement has been determined, the haemolytic system is standardised, and against this standardised haemolytic system the other ingredients of the test are titrated in order to determine the proper quantity of each to employ.

The antigen is titrated to ascertain its anticomplementary unit. The smallest amount which inhibits haemolysis is the anti-complementary unit Half that amount, or even less, is used in the final test.

After the titre of the antigen has been determined in the above-mentioned manner, and when carrying out subsequent tests in which fresh complement of an unknown titre has to be used, it is convenient, when ascertaining the M.H D. of complement, to titre it in the presence of the unit of antigen previously determined

Each bovine test serum is similarly titrated in order to determine the maximum amount which does not inhibit haemolysis. It was thought at first that a definite amount of test serum could be taken as a standard unit, and, provided the quantity of the standard unit was small enough, it would render a titration unnecessary. It was found, however, that the test sera differed very much in their behaviour towards complement, and that for accuracy in the final result it was necessary to titrate each serum separately. The controls in this titration are most important, and the unit of bovine serum to be determined is the largest amount which allows complete haemolysis to occur in the tube containing it in the same minimum time as complete haemolysis takes place in a tube containing only saline solution plus the titrated units of complement and sensitised red blood cell suspension.

The amount of each test serum to be used in the final test must be so determined that the amount employed is slightly less

than the largest amount which has been shown not to interfere with the complete haemolysis of the standardised haemolytic system it has been titrated against.

. Having ascertained the exact quantity of each ingredient to employ, the final test is now set up as follows, assuming for example that the quantity of each ingredient shown below is the titrated unit.

	Tube.	Antigen, 1 in 10.	Inactivated ox serum, 1 in 10.	Complement 1:30.	Saline.	Sensitised R.B.C. 5%
Group I.—						
Serum No. I (known positive serum)	1	·15	·1	·15	1·6	·5
	2	—	·1	·15	1·75	·5
	3	—	·1	—	1·9	·5
Group II.—						
Serum No. II. (known negative serum)	4	·15	·1	·15	1·6	·5
	5	—	·1	·15	1·75	·5
	6	—	·1	—	1·9	·5
Group III.—						
Serum No. III. (suspected serum to be tested)	7	·15	·1	·15	1·6	·5
	8	—	1	·15	1·75	·5
	9	—	·1	—	1·9	·5
Antigen control	10	·15	—	·15	1·7	·5
Complement control	11	—	—	·15	1·85	·5
Saline control	12	—	—	—	2	·5

Incubate for one hour at 37° C. Incubate at 37° C.

The first tube in each group of three contains antigen, and it is therefore the tube in which the particular serum is being tested. All other tubes in the series are controls.

The second tube in each group of three is the serum control for the particular serum of the group. This tube must show complete haemolysis before the reaction of the particular serum in the test can be recorded.

The third tube in each group of three is also a serum control, but in this tube complement is omitted. This tube serves as a control to show that the particular ox serum is not in itself haemolytic for the unit of sensitised R.B.C. No haemolysis should occur in this tube. After the first incubation for one hour has taken place, one unit of sensitised red blood cells is added to each tube, and the rack is then replaced in the incubator. The duration of the final incubation period varies usually from 10 to 30 minutes, and the tubes have to be carefully watched in order to note the appearance of haemolysis. Complete haemolysis must have taken place in both the antigen and compelment

control tubes (tubes 10 and 11), before a reading of the tubes containing the test serum is made.

If both the antigen and complement controls show complete haemolysis, the serum control tube of each particular serum being tested (tubes 2, 5, and 8) is next examined. If this tube shows complete haemolysis, its companion tube containing antigen is next examined. If the reaction is positive, this antigen tube should show no haemolysis at the time when its serum control tube shows complete haemolysis. If the reaction is negative, complete haemolysis will be shown in the antigen tube as well as in the serum control tube at the same time.

Border-line reactions sometimes occur, but their number is usually small, and certainly not greater than the number of such reactions obtained with complement fixation tests in other diseases.

It is important in reading the final result to observe the exact time required for haemolysis to occur in the controls, for, if the reading of the test is delayed it is possible for a serum to have shown fixation, and the fixation to become masked by a subsequent haemolysis. This subsequent haemolysis is due to the conglutinin present in the bovine serum, reinforcing the small amount of unfixed complement, and assisting that amount of complement to haemolyse more or less completely the sensitised red blood cells. This ability of conglutinin to augment the haemolytic power of a dose of complement, too small in itself to produce haemolysis, is strikingly shown in the experiment set out in detail on pages 44-45.

Results of Complement Fixation Tests.

Up to the time of writing this report, 63 different bovine sera have been tested for complement fixation in the manner just described. Of this number, 14 have given definite positive reactions, and 47 have given definite negative reactions, while two border line and doubtful reactions have been recorded.

In each case the reaction given to the test has been checked by a post-mortem examination of the animal supplying the particular serum tested.

A number of the animals tested were dairy cows from farms which were quarantined owing to the presence of contagious pleuro-pneumonia on them. These animals had each received a prophylactic injection of virus subcutaneously in the tail some

time prior to being tested. The length of time between the prophylactic injection, and the test varied from 15 days with one lot of animals to 6 months with another lot. It is worthy of note that in all cases where an animal which had been injected with virus subcutaneously in the tail was tested, the reaction to the test was negative, excepting in those cases where lesions of contagious pleuro-pneumonia could be demonstrated in the lungs on post-mortem examination, in which cases the reactions to the tests were positive.

Two of the animals tested had each reacted so violently to the prophylactic injection of virus in the tail, that portion of the tail was necrotic at the time that the blood sample was taken for testing. These two animals, on testing, gave negative complement fixation reactions, and showed no lesions of contagious pleuro-pneumonia in the lungs on post-mortem examination.

The sera tested, the results of the tests, and the post-mortem findings in each case can be tabulated as follow:—

Serum Number.	Result of Complement fixation test	Result of P M examination of the animal supplying the test serum
40	Positive	Active C P P, involving practically the whole of one lung
41	Negative	Hydatids in lung—no lesions of C.P P
42	Negative	No lesions of C.P.P
43	Negative	No lesions of C.P.P.
44	Negative	Tuberculosis in lungs and lymph glands. No lesions of C.P.P.
45	Negative	No lesions of C P.P.
46	Negative	No lesions of C.P.P
47	Negative	No lesions of C.P.P.
48	Positive	Small chronic encapsulated lesion of C P P. in one lung. Tuberculosis in pharyngeal lymph glands.
49	Positive	Active C P.P. involving whole of right lung.
50	Positive	Small and very early lesion of C.P.P. on margin of left lung.
51	Positive	Active C.P.P. involving practically the whole of the left lung.
52	Doubtful	Calf 2 days old. No lesions of C.P.P. Mother was infected (see No. 49).
53	Positive	No lesions of C.P.P. in the lungs. Animal had not been inoculated.
54	Negative	No lesions of C.P.P.
55	Negative	Extensive hydatid infestation. No lesions of C.P.P.

Serum Number.		Result of Complement fixation test.		Result of P M examinations of the animal supplying the test serum.
56	-	Negative	-	No lesions of C.P.P.
57	-	Negative	-	No lesions of C.P.P.
58	-	Negative	-	No lesions of C.P.P.
59	-	Negative	-	No lesions of C.P.P.
60	-	Positive	-	Old encapsulated lesion in left lung.
61	-	Negative	-	No lesions of C.P.P.
62	-	Positive	-	Small active lesions right lung.
63	-	Negative	-	No lesions of C.P.P
64	-	Negative	-	No lesions of C.P.P.
65	-	Negative	-	No lesions of C.P.P.
66	-	Positive	-	Small and early lesions of C.P.P. on margin right lung.
67	-	Negative	-	No lesions of C.P.P. Tuberculosis supra mammary gland and in udder.
68	-	Positive	-	Old chronic lesion in left lung with necrosis.
69	-	Negative	-	No lesions of C P P. Actinomycotic infection of the udder.
70	-	Negative	-	No lesions of C.P.P. Old adhesions between left lung and diaphragm.
71	-	Positive	-	Small active lesion in left lung, extensive exudate in chest cavity.
72	-	Negative	-	No lesions of C.P.P.
73	-	Negative	-	No lesions of C.P.P. Perforation by piece of wire through rumen and diaphragm to lung with adhesions and pus.
74	-	Negative	-	No lesions of C P.P.
75	-	Negative	-	No lesions of C.P.P.
76	-	Negative	-	No lesions of C.P.P.
77	-	Negative	-	No lesions of C.P.P.
78	-	Negative	-	No lesions of C.P P.
79	-	Negative	-	No lesions of C.P.P, extensive hydatid infection in lungs and liver
80	-	Negative	-	No lesions of C.P.P.
81	-	Negative	-	No lesions of C.P.P.
82	-	Positive	-	Active lesions involving practically whole of one lung, with adhesions between costal and pulmonary pleurae. Extensive exudate in chest cavity
83	-	Negative	-	Tuberculosis in lungs and lymph glands. No C.P.P.
84	-	Negative	-	No lesions of C.P.P.
85	-	Negative	-	Old adhesions between costal and pulmonary pleurae. No C.P.P.
86	-	Doubtful	-	No lesions of CP.P. in lungs.
87	-	Positive	-	Large chronic encapsulated lesion in one lung, with necrosis. Adhesions between lung and diaphragm.

Serum Number	Result of Complement fixation test.	Result of P.M. examination of the animal supplying the test serum.
88		
89		
90	Negative	No lesions of C.P.P.
91		
92		
93	Negative	Tuberculosis in lungs and lymph glands. No C.P.P.
94	Positive	Active lesions of C.P.P. in left lung, and fluid in chest cavity.
95		
96		
97		
98	Negative	No lesions of C.P.P.
99		
100		
101		
102		

The positive reaction given by No 53 is difficult to explain. The lungs of this animal were submitted to a searching post-mortem examination, but no lesions of contagious pleuro-pneumonia could be demonstrated in them.

No. 52 was a calf two days old The serum of this animal gave a border line reaction, which it was impossible to interpret, either as negative or positive This reaction might be explained by the fact that this animal, although not affected with contagious pleuro-pneumonia, was the progeny of an infected mother, who showed active lesions of the disease on post-mortem examination No. 86 was an apparently healthy bull, and no lesions of contagious pleuro-pneumonia could be demonstrated in the lungs on post-mortem This bull gave a border line reaction to the test, which could not be interpreted, either as negative or positive

It will thus be seen that, with the exception of the three reactions specially quoted, the complement fixation test has proved reliable in differentiating between animals which are, and which are not, affected, with contagious pleuro-pneumonia.

. . . . . .

During the progress of these latter complement fixation tests with alcoholic extracts as antigen, my attention was directed to an abstract, published in the *Tropical Veterinary Bulletin*, Vol. 8 (March 30th, 1920), p. 55, of an article, "Feststellung Der

Lungenseuche Mit Hilfe Der Komplementablenkung," by Titze and Gieze, published in the *Berliner Tierarztliche Wochenschrift*, No. 32, Vol. 35 (August, 1919, pp. 281-282). Unfortunately, I have not been able to see the original article by Titze and Gieze, but it would appear from the abstract already referred to that, while there are many points in common in regard to the reaction described by Titze and Gieze, and that which I have just described, they differ in certain very material points. Titze and Gieze used as antigen tissue the fresh lung and bronchial lymph glands taken from an infected animal. With this tissue they prepared:—

(1) A watery extract by boiling, afterwards centrifuging to obtain a clear solution, which was then made isotonic by the addition of the necessary quantity of sodium chloride.

(2) An alcoholic extract which was afterwards cleared in the centrifuge, and diluted with from 10 to 50 parts of saline solution. Since reading the abstract of Tietze and Gieze's work I have prepared, and tried alcoholic extracts of diseased lung. While it is possible to obtain complement fixation with such extracts, the results obtained with them have not been satisfactory, and in certain instances have been quite unreliable. I am thoroughly of the opinion that sub-epidermal tumour tissue is better material from which to prepare the antigen. Alcoholic extract of dried sub-epidermal tumour tissue gives uniform fixation, and thoroughly reliable results, if the technique laid down is carefully followed.

It is probable that an alcoholic extract prepared from fresh subepidermal tumour tissue will give equal, if not better, results than that prepared from dried tissue, but, at the present time, I have not had an opportunity of testing it.

Titze and Gieze mention the haemolysis which often occurs after a positive result, and quite correctly refer to the necessity of carefully titrating the complement, in order to ascertain the absolute M.H D. In the method of complement titration we differ in technique, but either method gives good results. While mention is made of the fact that haemolysis usually follows a positive result, Titze and Gieze apparently do not attempt to explain the phenomena which bring about that haemolysis

The tests which I have conducted, in order to determine the influence of conglutinin on haemolysis in the complement fixation test in contagious pleuro-pneumonia, offer an obvious explanation for its occurrence. It seems quite evident that the

conglutinin present in the test serum (bovine serum) reinforces a small amount of complement, which has not been fixed, and permits haemolysis of the sensitised red blood cells to occur.

The variation in time required for this haemolysis to occur in the test is due to the amount of complement and conglutinin present and capable of acting in combination to bring about haemolysis.

The amount of conglutinin present in bovine sera differs very considerably. It is on account of this variability in the conglutinin content of the test sera that I prefer to titrate each test serum separately, and thus arrive at the proper quantity of each to use in the final test.

Titze and Gieze apparently do not do this, but adopt as a standard amount approximately 0.1 c.c. of a 1 in 10 dilution. This latter method I have proved to be particularly prone to produce reactions which are not as sharply defined as when the test serum has been titrated, and the proper quantity, revealed by the titration, employed in the final test. With certain sera, such as those which give border line reactions, the proper titration of the test serum is an absolute essential to a reliable result in the final test, for an amount of serum either short of, or in excess of the proper quantity, would be sufficient to produce a totally different result to the proper one.

Experiments to Remove Conglutinin from Bovine Serum.

The results of the complement fixation experiments outlined in the previous chapter have proved that complement fixing antibodies are present in the sera of animals affected with contagious pleuro-pneumonia. It has also been demonstrated that by adopting a special technique, it is possible to test a serum for the presence or absence of these antibodies.

The presence of conglutinin in bovine serum has made the elaboration of a special technique necessary for this test, which requires very careful manipulation in all stages, and very careful observation in the final stage in order to guard against error in the final reading.

If conglutinin could be eliminated altogether from the bovine serum, it was thought that the test with sera deprived of conglutinin could be much simplified, and the necessity for careful and exact observation of the time required for haemolysis to occur in the final stage could be dispensed with.

Experiments were accordingly made in order to remove all traces of conglutinin from various bovine sera, which were afterwards tested to determine the effect the experiment had produced on their complement fixing properties.

Bordet and Gay. (3) have shown that conglutinin is not destroyed by heating bovine serum at a temperature of 56°C. To attempt to destroy conglutinin by heating at higher temperatures would probably render the serum useless for test purposes afterwards, consequently some other method had to be adopted in order to get rid of it. If inactivated bovine serum plus complement is added to a saline suspension of red blood cells previously sensitised by their specific sensitiser, conglutination of the red blood cells takes place more or less immediately on mixing, and in the reaction produced the conglutinin becomes used up. This conglutination is followed after a varying time by haemolysis of the red blood cells, the time depending on the source and activity of the complement used in the experiment. If, then, when conglutination occurs in such an experiment, and before haemolysis has time to occur, the mixture is rapidly centrifuged, the supernatent fluid can be pipetted off from the deposit of red blood cells, and will be found to contain little or no conglutinin; the absence of conglutinin depending on the degree of saturation of the bovine serum by the red blood cells. Thus it is possible to deprive a bovine serum of its conglutinin.

Certain bovine sera, which had been taken from animals known to be affected with active lesions of contagious pleuro-pneumonia, were used for experimental purposes. The experiments carrid out were as follows:—

Experiment 1.—To 10 c.c.s. of a 5 per cent. suspension in saline of washed red blood cells of a sheep, which have been previously sensitised by their specific amboceptor, 1 c c. of fresh horse serum is added. Mix, and allow to stand at room temperature for one hour. Haemolysis does not occur in one hour, because the horse serum—although it contains complement—contains only a very weak complement. Centrifuge the mixture, and carefully remove the fluid from the deposit of cells. The cells are then washed in saline solution, which is afterwards removed. Add then to the deposit of cells, 1 c.c. of saline solution, and 1 c.c. inactivated bovine serum (No. 51 positive). Conglutination of the red blood cells takes place almost immediately on mixing. Carefully remove the supernatent fluid, and dilute it 1 part in 4 of saline solution, thus forming a 1 in 10 dilution of the original amount

of bovine serum used. The complement fixing properties of this diluted serum are then tested. As a control, a 1 in 10 dilution of serum (No. 51) from the same bulk sample, but which has not been treated for extraction of conglutinin, is also tested.

The untreated serum gives a strongly positive reaction, when tested, whereas the treated serum gives a negative reaction. The treated serum is found to be devoid of conglutinin, but in the process of extracting the conglutinin, the specific complement fixing antibodies have also disappeared. It is thus apparent that serum so treated is rendered useless for the purpose of a complement fixation test for contagious pleuro-pneumonia.

Experiment 2.—To 3.5 c.c.s. of a 10 per cent. suspension of the washed red blood cells of a guinea-pig there is added 1 c.c. saline solution, and 0.5 c.c. of fresh horse serum. (Horse serum contains a natural sensitiser for guinea-pig's cells, the fresh horse serum also contains complement). Mix thoroughly by shaking, and allow to stand at room temperature for one hour, then centrifuge. Pipette off the fluid, and add 2 c.c.s. saline solution to the deposit of cells. Mix and centrifuge. Pipette off the saline solution, and add to the deposit of cells, 2 c.c.s. saline solution, and 0.5 c.c. inactivated bovine serum (Serum No. 94, positive). Mix, and allow to stand at room temperature for 30 minutes, then centrifuge. Carefully remove the fluid from the deposit of cells, and add to this fluid 2.5 c.c.s. of saline solution, thus forming a 1 in 10 dilution of the original amount of bovine serum used. This dilution of treated bovine serum is then tested for its complement fixing properties. It gives a feebly positive reaction, whereas untreated serum No. 94, from the same bulk sample, gives a strongly positive reaction. It is found, on testing, that the experiment to remove the conglutinin from the serum so treated, has failed to remove it completely, although the greater bulk of it has been extracted.

Experiment 3.—To 10 c.c.s. of a 10 per cent. suspension in saline solution of the washed red blood cells of a goat there is added 1 c.c. of fresh unheated bovine serum (Serum No. 94, positive). (Bovine serum contains a natural sensitiser for goat's cells, and fresh bovine serum also contains complement). Allow the mixture of serum and cells to stand at room temperature for 20 minutes. Conglutination of the red blood cells takes place a few minutes after the mixture is made. Centrifuge and carefully pipette off the supernatent fluid from the deposit of red blood cells. The supernatent fluid is bovine serum diluted 1 in 10

with saline, and it should now contain no conglutinin. The absence of conglutinin can be tested for by adding this supernatent fluid to another amount of washed goat cells, and noting whether any conglutination occurs. It has been found that one application of 10 c.c.s. of a 10 per cent. suspension of goat's cells was sufficient to extract all the conglutinin from 1 c.c. of any one of the bovine sera, which have been treated in this way. The bovine serum dilution, after the conglutinin has been extracted, is then heated in a water bath at 56°C. for 30 minutes, to destroy any complement which may remain. On submitting this treated bovine serum to a test for complement fixation, it is found that it gives a negative reaction, whereas untreated serum No. 94 gives a strongly positive reaction.

From the results obtained in the experiments outlined above it is obvious that, while it is possible to extract conglutinin from bovine serum, the extraction of conglutinin also brings about the disappearance of the specific antibodies; consequently, sera so treated are useless for the purposes of complement fixation tests for the diagnosis of contagious pleuro-pneumonia.

Conclusion.

(1) Agglutinins could not be demonstrated, in the serum taken from bovines known to be affected with contagious pleuro-pneumonia, by the usual macroscopic and microscopic methods of testing for agglutinins. Therefore an agglutination test apparently has no value as a means of differentiating between animals which are, and which are not, affected with the disease.

(2) Complement fixing antibodies are present in the serum of animals affected with the disease, and a complement fixation test can be used to differentiate infected from non-infected animals.

(3) In order to obtain reliable results with the complement fixation test, the special technique outlined in the proceeding pages must be closely followed in every particular.

(4) The main difficulty in carrying out complement fixation for the diagnosis of contagious pleuro-pneumonia is to prevent errors arising in the test owing to the presence of conglutinin in the test serum.

(5) Bovine serum, from which the conglutinin has been extracted by adopting the methods outlined in the preceding pages, is rendered useless for the purposes of a complement fixation test owing to the inability to prevent, with extraction of the con-

glutinin, the extraction also of the specific complement fixing antibodies.

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[PROC. ROY. SOC. VICTORIA, 33 (N.S.), 1921.]

ART. XIII.—*New or Little-known Victorian Fossils in the National Museum.*

PART XXV.—SOME SILURIAN TABULATE CORALS.

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(With Plates IX., X., XI.)

[Read 9th December, 1920.]

Introduction.

The limestones and originally calcareous mudstones of the Yeringian series of Victoria afford a rich field for research, especially in regard to the corals. The following six new species help to elucidate the undescribed tabulate forms, though there is a large number of the rugose corals still to be determined.

A new locality is recorded for *Favosites forbesi*, whilst the new species, *F. spinigera*, affords additional evidence, in its alliance to *F. grandipora*, in support of the subgeneric value of *Emmonsia*, Edwards and Haime.

The opportunity is here taken to enlarge on certain interesting morphological details concerning the remarkable coral, *Pleurodictyum*, the Victorian species of which, *P. megastomum*, has thrown much light on the relationship of the genus to others of the *Favositidae*.

Specially noteworthy is the record of a Silurian *Michelinia*, which bears all the characters of the later occurring species of the genus, of Devonian and Carboniferous ages.

The description of two new species of Silurian *Alveolites* from Cave Hill shows how little this coral fauna has been investigated.

The *Romingeria* is the second described species from the Australian palaeozoic, the genus, with some reservation, having been first noted by Etheridge from the Devonian Burdekin Limestone of Queensland.

Syringopora occurs for the second time in Silurian rocks in Australia; it is a common component of the Australian Devonian and Carboniferous faunas.

The genera and species herein described are:—

Favosites forbesi, Edwards and Haime.
Favosites (Emmonsia) spinigera, sp. nov.
Alveolites victoriae, sp. nov.
Alveolites regularis, sp. nov.
Pleurodictyum megastomum, Dun.
Michelinia progenitor, sp. nov.
Romingeria ramulosa, sp. nov.
Syringopora thomii, sp. nov.

Description of Species.

Class ANTHOZOA, (Corals).

Suborder TABULATA

Fam. FAVOSITIDAE.

Genus Favosites, Lamarck.

FAVOSITES FORBESI, Edwards and Haime.

Favosites forbesi, Edwards and Haime, 1855, Mon. Brit, Foss. Corals, (Pal. Soc. Mon.), p. 258, pl. lx., figs. 2, *2a-g*. Chapman, 1914, Rec. Geol. Surv. Vict., vol. III, pt 3, p. 308, pl. liii., fig. 9; pl lvi., fig. 27. Idem., 1920, ibid., vol. iv., pt. 2, p. 186, pl. xxii., figs. 16, 17.

Observations.—This coral is widely distributed in the Yeringian beds of the Victorian Silurian. It differs in no way from the British examples from the Wenlock Limestone. The normal massive form of the Silurian type, as distinguished from the Devonian nodular and branching forms, is here recorded for the first time from the blue-grey limestone of Cave Hill, Lilydale.

In the specimens now figured, which have a diameter of about two inches, the corallites are curved and irregular, with an average diameter of 1.5mm., rather short, and with the outlines four, five or six-sided. Septal spines are present, but small, with occasionally one long projecting spine which is thicker than usual. Tabulae are numerous, about 8 to 10 in 5mm. The mural pores are large, irregularly and widely spaced.

Occurrence.—Cave Hill, Lilydale (coll. F. Chapman); Also found at Deep Creek, Thomson River; Cowombat Creek; Gibbo River; Mitta Mitta River; Wombat Creek. Silurian (Yeringian).

Genus **Favosites**, Lamarck. Sub-genus **Emmonsia**, Edwards and Haime.

FAVOSITES (EMMONSIA) SPINIGERA, sp. nov.

Description.[1]—Corallum massive, probably roughly dome-shaped. Corallites prismatic with distinct double walls, sometimes hardly in contact; somewhat irregular in width, varying from .8 to 1.8mm. Tabulae numerous, about 8 in the space of 5mm. of two kinds, complete and incomplete The former are thin and mainly horizontal, but some are convex and others are concave or even occasionally oblique. The incomplete tabulae or squamulae are thick at the base, tapering to a thin edge and often strongly curved, extending nearly halfway across the tube. Septal spines long, about 8 in the cycle Mural pores large, rare, disposed along the middle of the prism wall.

Affinities.—That this striking species falls into the subgenus *Emmonsia* is evident from the presence of numerous incomplete and spinelike tabulae seen in section. It differs from *Favosites (Emmonsia) hemispherica*, Yandell and Shumard,[2] from the Upper Silurian and Devonian of Ontario, in having an equal number of complete and incomplete tabulae, and in the single row of large mural pores, whereas the Canadian specimens have a double row of small ones.

In *F. grandipora*, Eth. fil.[3], we have some of the characters seen in the above species, as in the spiniform tabulae, though not so well developed; the mural pores are also large and uniserial as in *F.* (*E.*) *spinigera*, but the breadth of the corallites in the latter is nearly twice as great

Observations—Nicholson held the view[4] that *Emmonsia* should be regarded as of subgeneric value only, for some specimens of a species show complete tabulae, whilst others have both complete and incomplete. Fraipont on the other hand regarded *Emmonsia* as a valid genus and pointed out the general trend of tabulate structure in the Favositid and allied corals, which pass from the horizontal character in the Silurian and Devonian

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1 The description is based on a slice of the coral, the original specimen of which has been mislaid

2. Contrib Geol Kentucky, 1847, p 7 See also Nicholson, Pal. Tabulate Corals, 1879, p. 67, pl III, figs 3, 3a, b.

3 Rec Austr Mus, vol I, No 3, 1890, p 61, pl VIII, figs 6-9

4 Pal. Tab. Corals, 1879, p 41 See also remarks by R. Etheridge (Junr) on the same point in Rec. Geol Surv., N S. Wales, vol. VI., pt. 3, 1899, p. 167.

to the incomplete or vesicular in the Devonian and Carboniferous formations[5].

Occurrence.—Silurian (Yeringian). Deep Creek, Thomson River, Gippsland. Collected and presented by the late Rev. A. W. Cresswell, M.A.

Genus **Alveolites**, Lamarck.

ALVEOLITES VICTORIAE, *sp. nov.*

Description.—Corallum forming large, more or less erect to hemispherical masses, of irregular, moderately thick-walled, curved corallites, triangular, square or pentagonal in cross section, rarely six-sided. Towards the exterior of the corallum the calices expand and the walls thicken. In transverse section the walls show a conspicuous median residual of a dark colour. Diameter of corallites 1 to 1.5mm. Mural pores large, circular or elliptical, seen disposed in the angles of the corallite. Tabulae thin, horizontal, slightly curved or oblique, 8 to 10 in 5mm. Height of corallum about 5cm.; width about 3.5cm. In many of the corallites the vertical ridge is seen in transverse section as a strong projecting tooth.

Affinities.—The present species resembles *A. suborbicularis*, Lam.[6] in the comparatively thick walls, as well as in the blunt-ended longitudinal ridge; the calices in the latter are, however, less regularly polygonal.

A species tentatively referred to *A. suborbicularis* was described by the present writer from the Yeringian of Deep Creek, Thomson River, Gippsland[7]. This specimen also has a thick septum or longitudinal ridge; the corallites increase rapidly from the base of attachment to the distal surface, and measure from 1 to 3mm. in transverse diameter. In this example, however, the calices were less regularly polygonal

A somewhat similar form to the above is figured by R. Etheridge jnr. from the Middle Devonian of Arthur's Creek, Burdekin Downs, Queensland[8], referred to as "*Alveolites* sp. indet" It differs very slightly from *A. victoriae* in having more irregular tabulae and more constant five or six-sided corallites.

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5. Sur les Affinites des Genres *Favosites, Emmonsia, Pleurodictyum et Michelinia.* Annales Soc. Geol. Belgique, vol. XVI, pt. I., 1889, p. 21

6. Hist. des Anim. sans Vert., 1816, vol. II., p. 186. See also Nicholson, Pal Tab Corals, 1879, p. 126, pl. VI., figs. 2, 2*a*, *b*, and woodcut, fig 20.

7. Chapman, Rec. Geol. Surv Vict. vol. III., pt. 2, 1914, p. 310, pl. LVIII., fig. 20.

8. Geol. and Palaeont. of Queensland, 1892, p. 54, pl. I, figs. 16-17.

Occurrence.—This species was found in the Silurian (Yeringian) of Cave Hill, Lilydale, by the writer in 1902.

ALVEOLITES REGULARIS, sp. nov.

Description.—Corallum compact, forming comparatively large masses, occasionally as low divergent branches. One specimen measures over 9cm. in expanse. Corallites polygonal or subtriangular to rounded, averaging .5mm. in diameter, with a strong projecting tooth, and very minute spiny septa. Walls of corallites moderately thick, divided by horizontal tabulae fairly regularly spaced, about 10 in 5mm. Pores rare, large, situated in the angles of corallites.

Affinities.—This form also shows certain characters common to *A. suborbicularis*, but is distinguished by the regularity of the corallites. It also approaches *A. vallorum*, Meek[9], a Devonian species of Canada, especially in the fine and delicate spiniferous septa.

Occurrence.—Silurian (Yeringian), Cave Hill, Lilydale. Type presented to the Museum by F. Chapman. Also found at Cooper's Creek, Thomson River, Gippsland; presented by the late Rev. A. W. Cresswell, M.A.

Genus **Pleurodictyum**, Goldfuss.

PLEURODICTYUM MEGASTOMUM, Dun.

Pleurodictyum megastoma, McCoy, 1867, Intercolonial Exhibition Essays, 1866. On the recent Zoology and Palaeontology of Victoria, p. 23 footnote (nomen nudum), also Ann. and Mag. Nat. Hist, 1867, ser. 3, vol. xx., p. 201.

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Pleurodictyum megastomum, Dun, (McCoy MS.), 1898, Proc. Roy. Soc. Vict., vol. x. (N.S.), pt. ii., p. 83, pl. iii., figs. 1, 2.

P. megastomum, Dun, Chapman, 1903, ibid., vol. xv. (N.S.), pt. ii., p. 105, pl. xvi., figs. 2-5. Idem, 1914, Australasian Fossils, p. 114 and fig. 69E.

9. Trans. Chicago Acad. Sci., vol. I, 1868, p. 88, pl. XI., figs. 9, 9a.

Characters of the corallum.—There is little to add to the technical description given by Mr. W. S. Dun, and later, by the writer, excepting to say that the corallum attains much larger dimensions than was then stated, a specimen before me, from the junction of the Woori Yallock and Yarra, indicating at least 3 corallites when complete.

The basal epitheca is perhaps more strongly concentrically wrinkled than in the other recorded species, and seems to have been also covered with a fine pustulation.

Intermural gemmation is shown by the intercalation of triangular corallites between the normal quadrangular corallites. The outline of the corallites in *P. megastomum* are either pentagonal or quadrangular (trapezoidal in shape), or broadly triangular when interpolated between other normal corallites. On the other hand the foreign species have mostly elongate rhomboid corallites as typically shown in *P. problematicum*, Goldfuss[10]; irregularly polygonal in *P. stylophora*, Eaton sp.[11]; and hexagonal in *P. amazonicum*, Katzer[12].

It seems impossible to separate the other so-called species, *P. lonsdalei*, Richter[13], found in Devonian strata in Thuringia, which seems to show a wider spacing of the peripheral corallites than usual, but which are of the typical form seen in *P. problematicum*.

There is one species, however, which does seem to simulate the Victorian form to some extent, viz., *P. constantinopolitanum*, Roemer[14], in the breadth and general shape of the corallites. This was obtained from the Devonian of the neighbourhood of Constantinople.

Like other representatives of the genus this tabulate coral is in the Victorian specimens only preserved as casts, in mudstone or sandstone. They differ from other species in the larger size of the corallites with more quadrate form and in being generally arranged in fewer cycles. In one mudstone cast, from loc. B. 23, the tabulae are fortunately shown as thin irregular plates, some-

10. Petrifacta Germaniae, vol I, 1826, p 113, pl XXXVIII, fig 18, vol II., p 286, pl CLX, fig. 19. Also G and F Sandberger, Verst Rhein Schicht. Nassau, 1850-6, p. 405, pl. XXXVII, figs 8, *8a-c*

11 *Astraea stylophora*, Eaton, Geol Text-book, 1832 *Pleurodictyum stylophorum*, Eaton sp., Nicholson, 1879, Pal Tab. Corals, p 148, pl VIII, figs. 1, *1a*, *b*, text-fig 22.

12. Geol. unt. Amazonasgebietes, Leipzig, 1903, p 192, pl IX, figs *1a-c*.

13 Zeitschr. d. deutsch. Geol Gesellsch, vol VII, 1855, pp 562, 563, text-fig. 5.

14. Neues Jahrb., 1863, p. 519, pl. V

times vesicular, between the vertical partitions or undeveloped septa[15].

Whilst a peculiar tubular worm-like body is commonly found at the base of the European and American forms, this has not occurred in the Victorian species. On the other hand, many of the specimens show an imprint of a crinoid stem firmly impressed, and in one specimen of mudstone there are two small individuals of this coral, each of which has affixed itself upon a small *Spirifer* (*S.* cf. *crispus*) as a *point d'appui.* Numerous septa are present in *P. megastomum* which are tuberculate or granulate, of a much coarser texture than that seen in *P. problematicum* and other allied species[16].

The epitheca is strong in the Victorian species and concentrically wrinkled like the foreign forms, and is also radiately marked with granulated lines.

The Remarkable Development of Pleurodictyum in the Devonian.—With the exception of the Victorian occurrence, this genus is confined to the Lower and Middle Devonian in Western Europe, Great Britain and North America. The question here arises, should our Yeringian fauna be regarded as Devonian rather than Silurian? It is true that several genera occurring in the Yeringian seem to support this view, such as *Phillipsastraea* and *Michelinia,* but on the other side of the argument, the evidence of the gasteropods, trilobites and ostracoda is overwhelming.

This constrains us at present to assume that certain forms of life appeared amongst this Gotlandian and Wenlockian facies earlier than in the northern hemisphere, and migrated thence during the transition period between the Silurian and Devonian epochs.

Note on Allied Genera.—

Cleistopora, Nicholson[17]. The genotype of this genus is Milne-Edwards and Haimes *Michelinia geometrica*[18]. It is a Devonian coral, discoidal, about 1.5 to 2cm. in diameter. It is said to be generally parasitic on a brachiopod, and in this respect resembles some Victorian specimens of *Pleurodictyum* herein mentioned. The short vertical corallites terminate in hexagonal

15 Nicholson, in his "Tabulate Corals," p. 148, et seq., gives an admirable account of the structure of *Pleurodictyum*, based on sections taken through the coralla of *P. stylophorum*

16. For further references to other species see Robinson, Trans. Connecticut Acad. Arts and Sci., vol. XXI., 1917, p. 169.

17. Geol. Mag., vol V., 1888, p. 150.

18. Polyp. foss. Terr. Pal., 1851, p. 252, pl. XVII., figs. 3, 3a.

calices. In this feature it differs from the Victorian *Pleurodictyum* but seems to agree with *P. amazonicum*, though the latter has comparatively long corallites. The visceral chamber is occupied by a mass of trabecular tissue formed by irregularly anastomosing fibres, and this structure is apparent on the floor of the calice. In *Pleurodictyum megastomum* on the contrary, septa are seen to be developed around the outer margin and feebly extend to the inner edge.

Vaughania, Garwood[19] is a Carboniferous coral having certain affinities both with *Cleistopora* and *Pleurodictyum*. From *Cleistopora* it differs in having no trabecular tissue at the floor of the calice, the corallum being formed of compact fibrous coenenchyma; it has a definite system of ring-canals and branches and a basal epitheca as in *Pleurodictyum*. From the latter genus it differs in the vertical calices and absence of tabulae and septal spines, but has intermural pores.

Occurrence.—Pleurodictyum megastomum is one of the typical fossils of the Yeringian Series of Victoria The figured specimen, built on a *Spirifer*, was collected by Mr. R H Annear from Hughes' Quarry near Lilydale; whilst the small but complete corallum was presented by Mr. A. M. Savige and came from Kinglake West.

The localities for *P. megastomum* are:—

In the Lilydale and Upper Yarra districts.—Hughes' Quarry (R. H. Annear); Ruddock's Quarry (F. P Spry, J. S. Green, F. Chapman); Wilson's Quarry (J. T. Jutson); Seville (J. S. Green); 1½ miles below Simmon's Bridge Hut on the Yarra (Geol. Surv. Vict. B. 16)[20]; junction of Woori Yallock and Yarra (Geol. Surv. Vict. B. 23); Woori Yallock, Mr. J. H. Syme's Orchard (F. Chapman).

In Gippsland.—Loyola near Mansfield; Thomson River; Cooper's Creek, Thomson River (Rev. A. W. Cresswell and A. A. Henderson).

District of Plenty Ranges.—Kinglake West (A. M. Savige); Clonbinane; Wandong (F. P. Spry); Merriang Road near Kilmore (J. T. Jutson); Kilmore (G Sweet).

In addition to these localitites the same species is apparently found at Zeehan in Tasmania (R. Etheridge jnr. and Rev H. Anderson), and also at Yass, N. S. Wales (W. S. Dun).

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19. Quart. Journ. Geol. Soc., vol LVIII, 1912, p 504

20. This locality was referred to in error as "West of Mount Disappointment," in my paper—Proc. R. Soc, Vict., vol. XV. (N S.), pt II, 1903, p. 107.

Genus **Michelinia**, de Koninck.

MICHELINIA PROGENITOR, sp. nov.

Description.—Corallum hemispherical, rather depressed. Corallites small, walls thick, having a diameter of 2 to 3mm., prismatic, chiefly hexagonal in transverse section. Tubes of corallites filled with funnel-shaped tabulae, at times regularly inserted centrally to form a cornute tube. Height of corallum about 3.5cm. (nearly one and a-half inches); expanse of specimen about 6.5cm. (about two and a-half inches).

Observations.—It is of very great interest to find a typical representative of the genus *Michelinia* so far down in the palaeozoic series. *Michelinia* is known from the Devonian of Canada, Devonshire and Asia Minor, and more profusely from the Carboniferous limestone of England and Russia; whilst in the Australian coral fauna, up to the present two identifications of this genus have been made, viz., *Michelinia* sp. cf. *tenuiseptata*, Phillips sp from the Carbopermian of Co. Buckland, N. S. Wales (probably Upper Marine Series)[21] and another from the Carboniferous of Lion Creek, Stanwell, near Rockhampton, Queensland[22]. The calices of the former have a diameter of 7-9mm. and the tabulae consist of much more crowded and irregular vesicular tissue. In the Queensland specimen the corallites have a diameter of 2-4mm. The tabulae are stated to be very numerous and anastomose freely, but do not appear to show the funnel-shaped arrangement of the Victorian form. It is not specifically named.

The present species, by far the oldest known, is a small celled, neat and thoroughly typical example of the genus. A distinguishing feature of the corallite structure is the great depth of the funnel-shaped tabulae.

Occurrence.—A well preserved specimen in whitish limestone from Cave Hill, Lilydale; coll. by Mr. R. H. Annear. Silurian (Yeringian).

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21 R Etheridge (junr), Mem. Geol Surv. N.S Wales Pal. No 5, 1891, p. 28, pl IV, fig. 1 See also Ed. and Haime, Mon. Brit. Foss Corals, 1852, pt. 3 (Mon Pal Soc.), p 155, pl. XLIV, figs 1, 1*a*, *b*.

22. R Etheridge (junr.) Bull. Geol. Surv, Queensland, No. 12, 1900, p. 7.

Fam. AULOPORIDAE.

Genus **Romingeria**, Nicholson

ROMINGERIA RAMULOSA, sp. nov.

Specific Characters.—Corallum apparently attached by the base only, afterwards free; branching at intervals, sometimes forming verticils of three branches. Corallites slender, elongate, trumpet-shaped; walls perforate. Tabulae thin, slightly concave and numerous. External surface of corallites sometimes facetted or angulate; epitheca finely wrinkled transversely.

Dimensions.—Length of corallites from 4 to 8mm.; width at mouth from 2.75 to 3mm.

Remarks and Affinities.—As regards the relationship of *Aulopora* to the present genus, Nicholson[23] said that he was "constrained to separate *Romingeria* from the *Auloporidae* as it possesses 'mural pores' in parts, while it further differs from *Aulopora* proper in having an erect corallum."

This perforate character in the present form of *Romingeria* is very well accentuated, nevertheless the whole build of the coral with this exception points to a close relationship with the better-known auloporoids.

In certain epithecal characters the present species reminds one of *Pleurodictyum*, one of the *Favositidae*, so that were it necessary to make a separation, *Romingeria* might eventually find a place in that family.

That this present species falls into the genus *Romingeria* is fairly clear from the fact that the corallum is free, excepting possibly at the base, unlike *Aulopora* which is attached from the base upwards to the terminals. One of the distinguishing characters which marks off the known *Romingeriae* from the auloporoid *Syringoporae* is its habit of forming verticils of corallites. This feature is also present, though feebly so, in *Romingeria ramulosa*. The genus is new to the Australian palaeozoic, with the exception of *Romingeria foordi* described by R. Etheridge jnr. from the Devonian of Reid Gap, near Townsville, Queensland[24].

Range of Genus.—*Romingeria* (formerly *Quenstedtia* of Rominger) has a geological range from the Silurian to the Devon-

23. On the Structure and Affinities of the Tabulate Corals of the Palaeozoic Period, 1879, p 231

24. Geol and Palaeont. of Queensland, 1892, p 56 pl I, fig 13

ian, and hitherto confined to the North American area. *R. umbellifera*, Billings sp.[25] is found in the Corniferous Limestone (Lower Devonian) of Wainfleet, Lake Erie, Canada West; whilst a Silurian species, *R. niagarensis*, Rominger sp.[26] occurs in the Niagara Group, Upper Silurian, at Port Detour, Lake Huron, and also at Iowa.

Occurrence.—Abundant as well preserved ochreous-coated casts in the olive-brown mudstone of Ruddock's Quarry, near Lilydale. Silurian (Yeringian).

Fam. SYRINGOPORIDAE.

Genus **Syringopora**, Goldfuss.

SYRINGOPORA THOMII, sp. nov.

Description.—Corallum moderately large; corallites in fairly close contiguity, about 2cm or more in length, connected by short epithecal stolons Calices filled with both funnel-shaped tabulae and numerous dissepiments which are confined to the sides. Walls of corallites thick, measured about .75 mm.; average diameter of calices, 3 to 4.6mm. Septa minute, spines about 40 to the cycle.

Observations—The calices in this species are exceptionally large for the genus, but are more than matched by the Middle Devonian *S. spelaeanus*, Eth. fil.[27] found at Cave Flat, Murrumbidgee River, N. S Wales, and at Buchan, Victoria. The latter species differs however, in having much more widely separated corallites, which measure 5 5 to 6mm in diameter. The corallites of *S. spelaeanus* measure about 5 or 6 inches in length, against three quarters of an inch in S. thomii.

The walls of the Victorian species are not so thick as in *S. porteri*, Eth. fil[28] of the Tamworth Limestone (Mid. Devonian), which also has smaller corallites (1.5 to 2mm. in diameter).

Syringopora syrinx, Eth. fil.[29] from the Carboniferous Limestone of Lion Creek, near Rockhampton has smaller calices than

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25. *Aulopora umbellifera*, Billings. Canadian Journ. (N.S.), vol. IV, 1859, p 119

26 *Quenstedtia nigarensis*, Rominger, Geol. Surv of Michigan, vol III., pt. II, 1876, p 72, pl XXXIII., fig. 3 (lower specimen).

27. Rec. Austr Mus, vol. IV, No. 7, 1902, p 258, pl. XXXVII., fig. 2; pl. XXXVIII.

28 Rec Geol. Surv, N S Wales, vol. VI, pt 3, 1899, p. 176, pl XVIII., fig. 3, pl XXXI., figs 1, 2

29 Bull Soc. Geol Surv, Queensland, No. 12, 1900, p. 6, pl. I, figs, 6-9, pl. II, fig. 11.

the Victorian species, and it also differs in the greater amount of vesicular tissue within the tubes. Otherwise there is some resemblance between them.

S. bellensis, Eth. fil.[30] from the Silurian of the Wellington Caves, N. S. Wales, has smaller calices, with more regular circular openings. The same close contiguity is observable in both species.

Occurrence.—The type specimen is from the grey limestone of Loyola, near Mansfield, and was presented by the Rev. Robert Thom, after whom the coral is named, in recognition of his successful work in discovering many interesting fossil remains in the palaeozoic rocks of Victoria.

Also found in the limestone of Cave Hill, Lilydale; several specimens presented by C. S Buckley Esq. Silurian (Yeringian).

EXPLANATION OF PLATES.

Plate IX

Fig. 1.—*Favosites forbesi,* Edwards and Haime. Fractured vertical section of corallum Silurian (Yeringian). Cave Hill, Lilydale. Plesiotype. C S Buckley coll. Nat size

Fig. 2.—*F. forbesi,* Ed and H Fractured transverse section of another specimen. Silurian (Yeringian). Cave Hill, Lilydale. Plesiotype. C. S. Buckley coll. Nat. size.

Fig. 3.—*Alveolites regularis,* sp nov. Calicular aspect. Silurian (Yeringian), Cooper's Creek, Thomson River, Gippsland. Paratype. Rev. A. W. Cresswell coll. Nat. size.

Fig. 4.—*Pleurodictyum megastomum,* Dun. Base of corallum with wrinkled epitheca, showing *Spirifer* at centre; also another adjacent example. Silurian (Yeringian). Hughes' Quarry, near Lilydale. R. H. Annear coll Nat. size.

Fig. 5.—*P. megastomum,* Dun. Wax squeeze from fig. 6, showing positive appearance of corallum. x $\frac{6}{8}$.

Fig. 6.—*P. megastomum,* Dun. Mud cast of corallum. Silurian (Yeringian). Kinglake West. A. M. Savige coll. x $\frac{6}{8}$.

Fig. 7.—*Michelinia progenitor,* sp. nov. Fractured surface, transverse section. Silurian (Yeringian). Cave Hill, Lilydale. Holotype. R. H. Annear coll. Nat. size.

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30. Rec. Geol. Surv. N.S. Wales, vol. V., pt. 4, 1898, p 156, pl. XVI.

Fig. 8.—*M. progenitor,* sp. nov. Vertical section through corallites. Silurian (Yeringian). Cave Hill, Lilydale. R. H. Annear coll. Nat. size.

PLATE X.

Fig. 9.—*Michelinia progenitor,* sp. nov. Vertical section showing infundibuliform tabulae. Silurian (Yeringian). Cave Hill, Lilydale. R. H. Annear coll. x 3.

Fig. 10.—*Romingeria ramulosa,* sp. nov. Corallum in mudstone. Silurian (Yeringian). Ruddock's Quarry, near Lilydale. Holotype. J. S. Green coll. Nat. size.

Fig. 11.—*R. ramulosa,* sp. nov. Corallites weathered, in mudstone, showing perforated walls and impressions of tabulae. Silurian (Yeringian). Ruddock's Quarry, near Lilydale. Paratype. W. J. Parr coll. x 10.

Fig. 12.—*R. ramulosa,* sp. nov. Enlarged outline of corallum, seen in fig. 10. Silurian (Yeringian). Ruddock's Quarry, near Lilydale. x 2.

Fig. 13.—*R. ramulosa,* sp. nov. Enlarged drawing of another specimen from the same locality, showing three corallites in verticil. Paratype. F. C. coll. x 2.

Fig. 14.—*Syringopora thomii,* sp. nov. Corallum, weathered, in grey limestone. Silurian (Yeringian.) Loyola, near Mansfield. Holotype. Rev. Robert Thom coll. Nat. size.

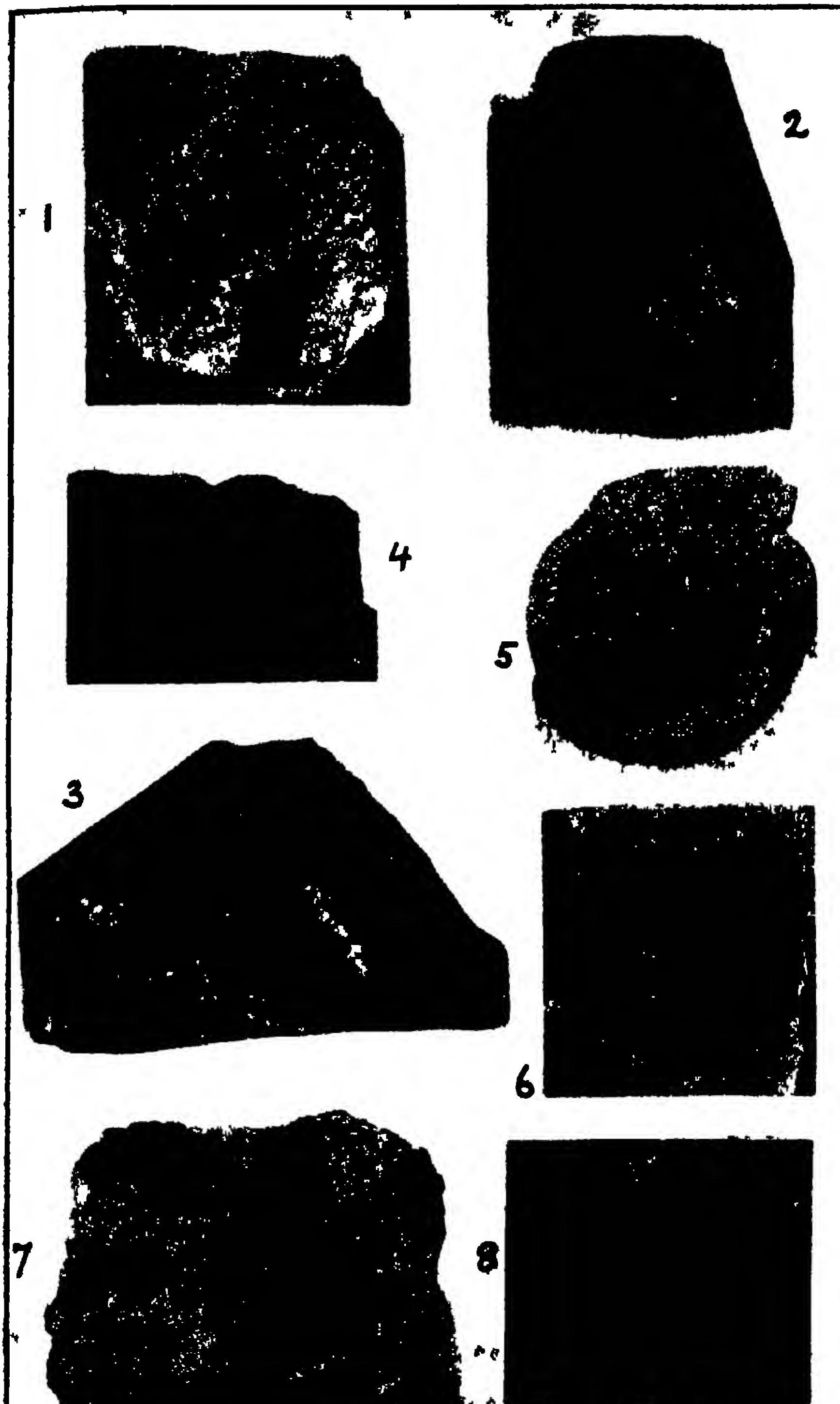
Fig. 15.—*S. thomii,* sp. nov. Section across corallum. Silurian (Yeringian). Cave Hill, Lilydale. Paratype. C. S. Buckley coll. Nat. size.

Fig. 16.—*S. thomii,* sp. nov. Section across corallite, showing dentate septa and curved tabulae. Silurian (Yeringian). Loyola, near Mansfield. Tectotype. R. Thom coll. x 10.

PLATE XI

Fig. 17.—*Aveolites victoriae,* sp. nov. Vertical micro-section showing irregular walls, large mural pores and thin tabulae. Silurian (Yeringian) Cave Hill, Lilydale. Tectotype. x 16.

Fig. 18.—*A. victoriae,* sp. nov. Transverse micro-section, showing irregular, polygonal calices and thick tooth of vertical ridge. Silurian (Yeringian). Cave Hill, Lilydale. Tectotype. x 16.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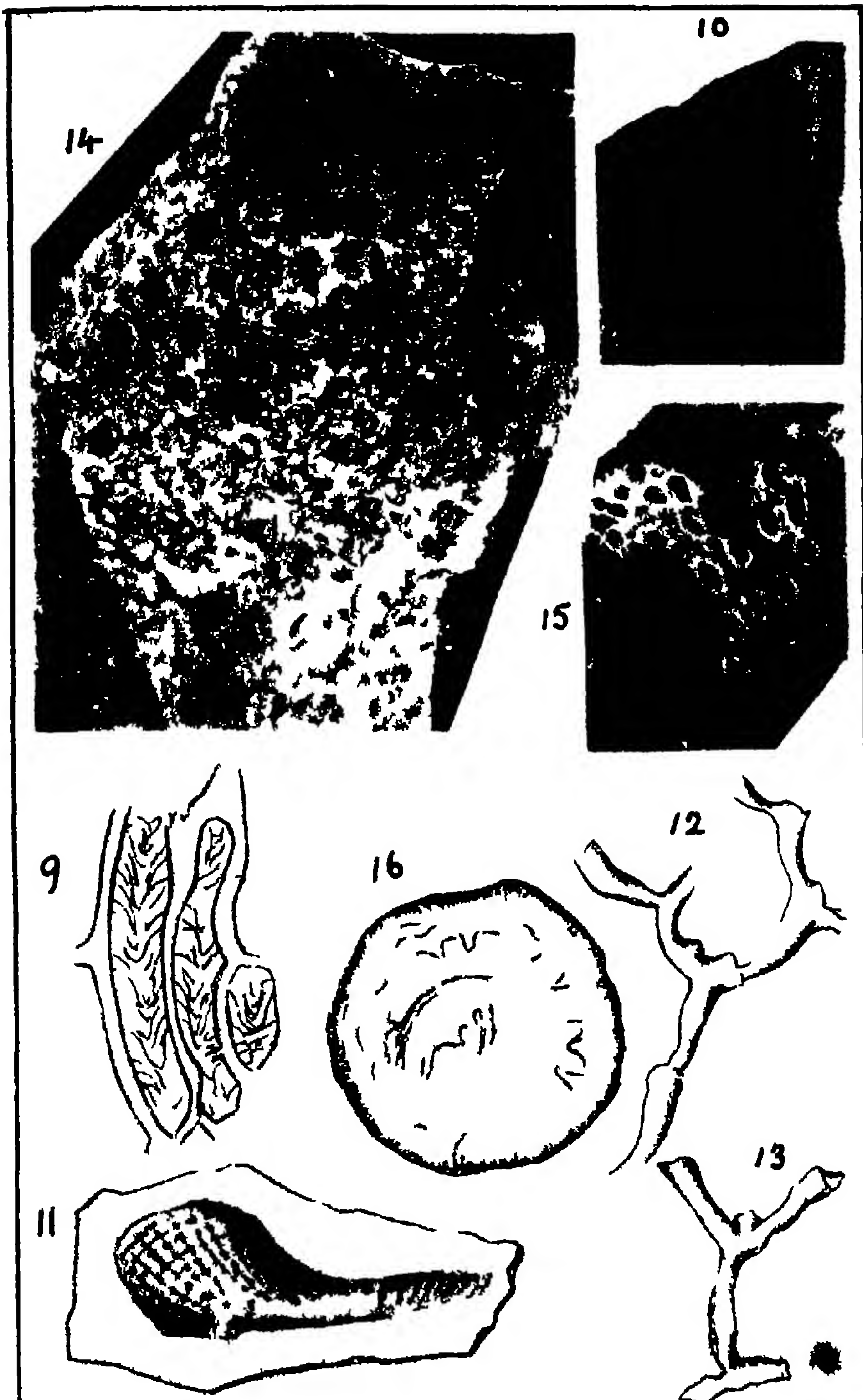

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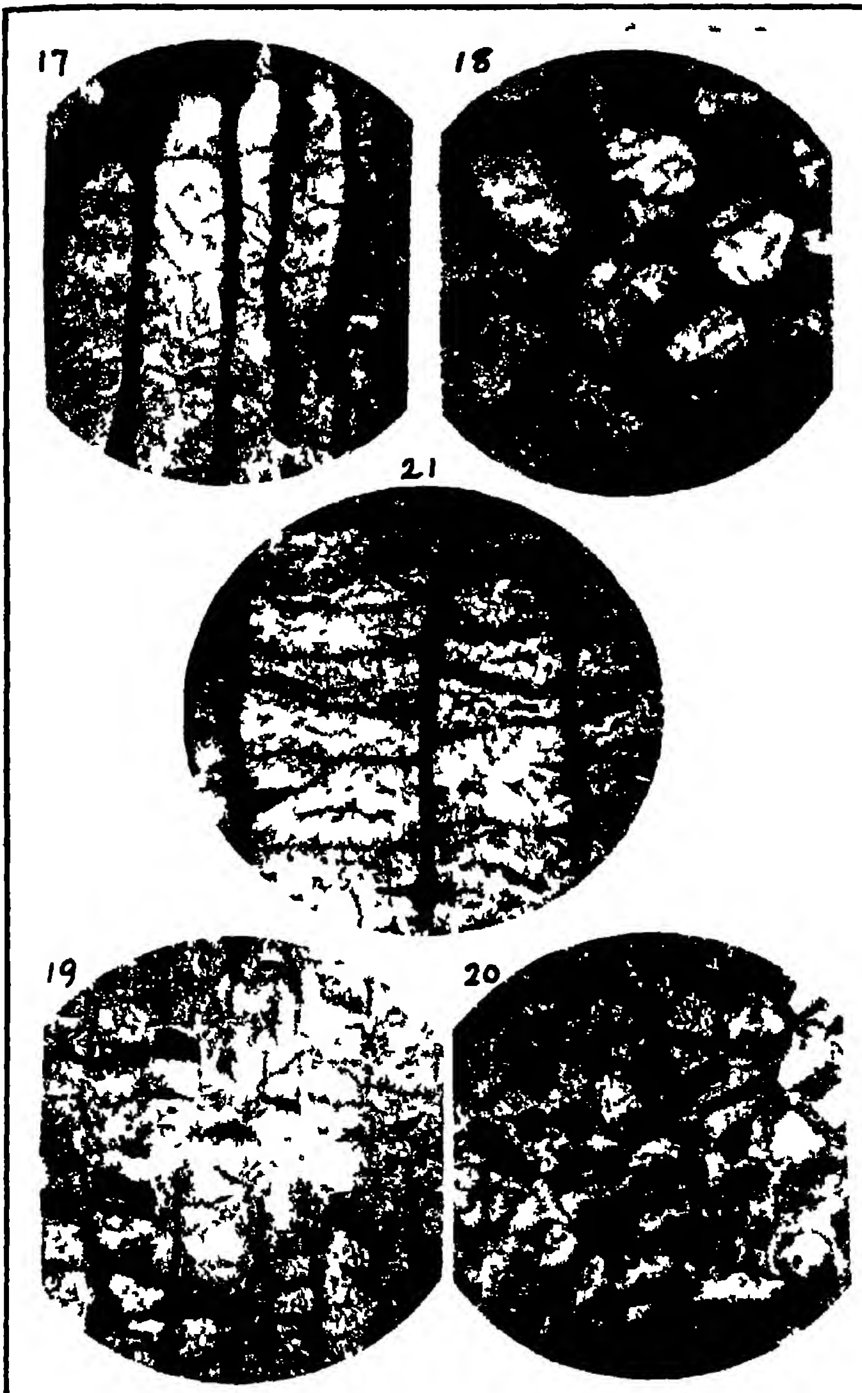
Michelina Romingera Syringopora



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Alveolites and Favosites

Fig 19—*Alveolites regularis*, sp nov Vertical micro section showing regular walls and thick tabulae. Silurian (Yeringian) Cave Hill, Lilydale Tectotype x 16

Fig 20—*A regularis*, sp nov Transverse micro section showing triangular to polygonal calices with blunt projecting ridge Silurian (Yeringian) Cave Hill Lilydale, Tectotype x 16

Fig 21—*Favosites (Emmonsia) spinigera* sp nov Vertical section showing thin complete tabulae and curved spiniferous, incomplete tabulae or squamulae Silurian (Yeringian) Deep Creek Thomson River Gippsland Holotype A W Cresswell coll x 16

[Proc Roy Soc. Victoria 33 (N.S.), 1921]

Art. XIV—Contributions to the Flora of Australia, No. 29.

BY

ALFRED J. EWART, D.Sc., Ph.D, F.L.S.
(Professor of Botany and Plant Physiology in the Melbourne University).

[Read 9th December, 1920.]

Asperula scoparia, Hook, f var. elongata, Benth. (Rubiaceae).

Borroloola, Northern Territory, G. F. Hill. No. 692, 14/12/1911, Five mile Bar, MacArthur River, Northern Territory, G. F. Hill. No. 730, 30/1/1912.

Bartsia trixago, L "Trixago Bartsia." (Scrophulariaceae).

Ullina, J. T. Mulquiny, 10/11/1920; Canterbury, C. French, Jnr. November, 1920. New localities in Victoria for this introduced plant.

It is a native of Europe and Africa and is semi-parasitic on roots of grasses, and its presence deteriorates a pasture. Mowing to prevent seeding, loosening and manuring the soil, aid in keeping it down.

Bassia quinquecuspis, F v M., var. villosa, Benth. "Spearfruited Saltbush" (Chenopodiaceae).

Sunbury, Victoria, C. Green, March, 1920.

This variety is now evidently spreading Southward in Victoria, having been previously recorded from the North West and the North Eastern Districts only.

Beyeria virgata, n. sp. (Text Fig). (Euphorbiaceae).

On Sand Hills near Lefroy in West Australia, 7/11/1891, R. Helms, Elder Exploring Expedition.

This plant was placed for a long time under *B. brevifolia,* from which species it is quite different. As it appeared to be undescribed, portion was sent to Kew, England, under the name of *Beyeria* and was returned marked, "Genus correct, species

unpublished." The specimens were held for a time in the hope of obtaining complete material with flowers, but as these have not been obtained, a description of the original specimens is now published.

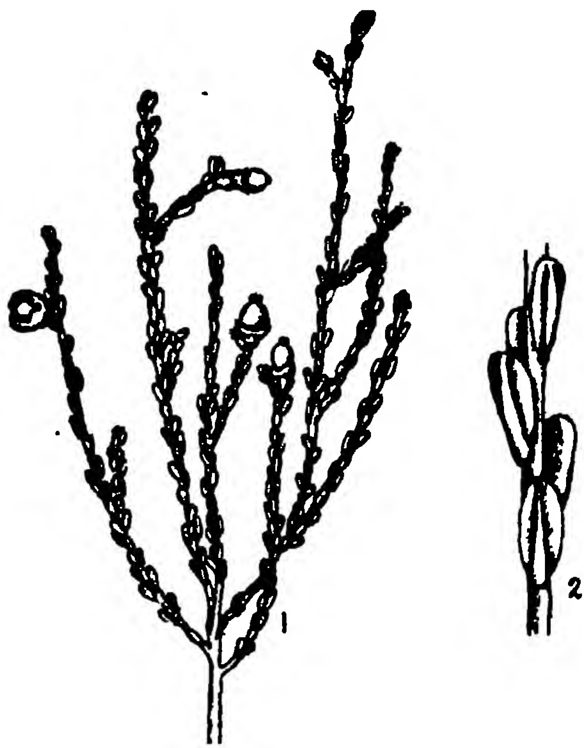


Fig 1 Shoot of *Beyeria virgata*, Ewart. (a) Capsule showing a single seed.
Fig. 2 Portion of shoot enlarged.

A rather compact woody shrub from 3 to 5 feet high, with tough greyish virgate branches, the ends covered by densely set very small sessile leaves. The leaves are about 2 mm. long by 1 mm. broad, thick, oblong with a relatively broad prominent midrib beneath, flat above, quite glabrous and glaucous. Female flowers scattered singly, sessile, terminal or lateral, stigms 2 Fruit a small, dry oval capsule, with a single seed, and splitting by five valves.

CLAYTONIA PERFOLIATA, Don. "Perfoliate Claytonia" (Portulacaceae)

Golton South, Victoria, A. W. Howard, September, 1920. Another locality in Victoria for this introduced plant.

ELEUSINE INDICA, Gaertn. (Gramineae).

The specimen from Borroloola, G. F. Hill, No. 606, 9/10/1911, given under *Leptochloa subdigitata,* Trin., on page 47 of the Flora of the Northern Territory should be transferred to *Eleusine indica, Gaertn.* This makes an addition to the list of grasses of the Northern Territory.

ERICA LUSITANICA, Rud. "Spanish Heath" (Ericaceae)

Wheeler's Hill, Victoria, J. W. Audas, 11/8/1916; Beaconsfield, Victoria, Mrs Dancocks, December, 1916; Selby, Victoria, C. French, Jnr.

The above was recorded in the Victorian Naturalist, vol. xxxiii., p. 69 (1916), and the Proceedings of the Royal Society of Victoria, vol. xxix, p. 145 (1916), under the name of *Erica arborea,* L. These two species though bearing a superficial resemblance are quite distinct, thus:—

E. LUSITANICA	E. ARBOREA
Shrub—10 to 12 feet high.	*Tree*—10 to 20 feet high
Branches—Clothed with simple hairs.	*Branches*—Tomentose.
Leaves—½-inch long, grooved beneath, irregularly arranged	*Leaves*—Grooved beneath, 3-4 in a whorl.
Flowers—Slightly fragrant.	*Flowers*—Fragrant (smells like honey).
Corolla—Cylindrical, about ¼-inch long	*Corolla*—Bell shaped or globular, ⅛ inch long.
Stigma—Small, red	*Stigma*—Flattened, white

E. lusitanica is a native of Western Europe; *E. arborea* is native to the Mediterranean regions and the Caucas.

The true *Erica arborea,* L. has been recorded as naturalised in the Research District, Victoria.

EUCALYPTUS MINIATA, A. Cunn. (Myrtaceae).

Mr Maiden states that the specimen, No. 809, given under the above heading in the Appendix iii. to the Flora of the Northern Territory, p. 312, belongs to *E. ptychocarpa,* F.v.M., and should be transferred to that species on the same page.

FRANKENIA SETOSA, W. V. Fitzg. (Frankeniaceae).

East Geraldton, West Australia, 1889 (without collector's name).

An additional locality in West Australia for this plant.

GREVILLEA CERATOCARPA, Diels. (Proteaceae).

Boodalin, West Australia, Lat. 31.13°, Long 120° East. A Forrest.

GREVILLEA INCRASSATA, Diels (Proteaceae).

Parkers' Range, West Australia, Edwin Merrall, 1892.

KYLLINGIA INTERMEDIA, R Br. "Globe Kyllingia." (Cyperaceae).

Water Reserve, South Mandurang, near Bendigo, March, 1919, also Water Reserve, Big Hill, near Bendigo, Victoria, March, 1920, David J. Paton.

New localities in Victoria for this plant, it having been previously recorded from the North Eastern District only.

MEDICAGO ECHINUS, D C "Cavalry Medick" or "Crown of Thorns" (Leguminosae).

Garden at Ballarat, H. B Williamson, September, 1916; Drysdale District, E Dennis, December, 1920

A native of the Mediterranean Regions. This plant is evidently spreading in Victoria and is apt to become a pest on account of its burred fruits

MEDICAGO MINIMA, L. "Small Burr-Medick" (Leguminosae).

Longerenong Agricultural College grounds Dooen, Victoria, a new locality for this plant.

A native of Europe and Asia. It was previously recorded as a naturalised alien in the South and South Western districts of this State.

MICROCALA FILIFORMIS, Hoff. and Link "Slender Microcala" (Gentianaceae).

Ringwood, Victoria, C. French, Jnr. October, 1920.

A new locality in this State for this introduced plant. It was previously recorded from Linton and Langwarrin.

MILLA UNIFLORA, R Grahm. Triplet Lily. (Liliaceae).

Beaumaris, Victoria, Alfred J. Tadgell, 11/9/1920.

A new locality for this garden escape. It is a native of South America.

Muscari botryoides, Mill. "Blue Grape Hyacinth." (Liliaceae).

Somerville, Victoria, J. W. Audas. September, 1916.

A native of Europe and Asia. This garden plant was found growing in the scrub along the main road, and may be classed as an exotic not yet sufficiently established to be considered naturalised.

Muscari racemosum, Mill. "Clustered Grape Hyacinth" (Liliaceae).

Sale, Gippsland, A. W. Howitt (1883).

A native of the Mediterranean Regions and the Caucasus. It is often cultivated in gardens, and like the preceding species, may be classed as an exotic not yet sufficiently established to be considered naturalised.

Notholaena distans, R.Br. (Filices).

On Sandstone Ranges, Borroloola, Northern Territory, G. F. Hill. No. 726, 13/12/1911.

Panicum piligerum, F.v.M (Gramineae)

Five Mile Bar, MacArthur River, Northern Territory, G F. Hill. No 703, 30/12/1911.

Panicum repens, L. (Gramineae).

Five Mile Bar, MacArthur River, Northern Territory, G. F. Hill. No. 736, 28/1/1912.

This is an addition to the Flora of the Northern Territory.

Pimelea hussyana, F.v.M. (nomen nudum) (Thymeleaceae).

Victorian Naturalist xi., p. 122 (1894). Trans. Roy. Soc. of South Australia, xix., p 81. (1895).

Both are citations of the name only, without any description, and no record of any published description can be found. The plant appears to be a good species and shows some affinities to *Pimelea alpina* The corolla however appears to be circumsciss, and the flowers in little terminal heads, which would give an affinity to *P. curviflora*. The following description would serve.

P. Husseyana. A small, wiry, branched shrub, a foot or more in height, with alternate, rarely opposite, closely set leaves, oval,

flat or slightly concave, with a prominent midrib, glaucous, drying with a bluish tinge, 3-5 mm. long. Stems hairy. Bracts but little broader than the foliage, leaves merging into them, usually at least 3 bracts can be distinguished. Flowers longer than the bracts, about 1 c.m., with a long tube, mostly apparently hermaphrodite; corolla silky villous outside, glabrous within. Filaments short, anthers flat. Fruit not seen. It was collected near Port Elliot, Encounter Bay, South Australia, by Miss J. Hussey, 1894.

POLYGONUM ARTICULATUM, R Br. (Polygonaceae).

Darwin, Northern Territory, M. Holtze, No 1244 (1891).

This is an addition to the Flora of the Northern Territory; it was previously recorded from Queensland

PSAMMOMYA, Diels and Loes. (Celastraceae).

This genus was described by Diels and Loesener in Engler's Botan., Jahrb, Bd. xxxv, p. 339 (1905). They state that what was described by F. v Mueller in the Victorian Naturalist, vol vi., p. 118 (1889), as *Logania choretroides* does not belong to the Loganiaceae and should be transferred to the *Celastraceae* under the above named genus. They have divided it into two species, namely *P. choretroides* and *P. ephedroides*, but through some error the specimen from Mount Narryer, Murchison River, I. Tyson, 1893, is given under *P choretroides*. It should have been placed under *P. ephedroides* as it agrees with the illustration given by Diels on page 341. The specimen from towards King George's Sound is quoted under *P. ephedroides* but obviously belongs to *P. choretroides*.

The distribution of these two species, according to the specimens in the National Herbarium, Melbourne, are:—

P. choretroides, Diels et Loes, Eastern Sources of the Swan River, Mrs. Heal, 1899; towards King George's Sound, 1892; Cowcowing, Max Koch, September, 1904.

P. ephedroides, Diels et Loes, Mt Narryer, Murchison River, Isaac Tyson, 1893. So far as we know at present this genus is confined to West Australia.

PTILOTUS, R.Br., and Trichinium, R Br. (Amarantaceae).

The species given under these two genera in the Flora of the Northern Territory, pages 97 to 100, should be transposed, i.e.,

those under *Ptilotus* should be put under *Trichinium*, whilst those under *Trichinium* should be placed under *Ptilotus*. F. Mueller, in his Census of Australian Plants, placed *Trichinium* as a sub-genus of *Ptilotus*. This arrangement is followed in Engler's Pflanzen Familien, and Maiden's Census of New South Wales Plants. In the Flora Australiensis, Bentham keeps them separate, but considers that if they were to be united it would be preferable to adopt *Trichinium*, as it contains the larger number of species, and would therefore cause the least confusion with the nomenclature of the species

For the sake of convenience they were kept separate in the Flora of the Northern Territory, and the generic names were accidentally transposed

SCLEROCHLOA DURA, Beauv. "Hard Grass" (Gramineae).

Longerenong Agricultural College grounds, Dooen, Victoria, A. C. Drevermann, October, 1920.

A native of Europe, Asia and Africa An exotic not yet sufficiently established to be considered naturalised. It is two small to be of much use as a pasture grass

SELAGINELLA STOLONIFERA, Spring "Creeping Selaginella" or "Cubmoss" (Selaginellaceae).

Malleson's Glen, Don River, Victoria, F G A Barnard 26/4/1920

This well-known greenhouse plant, a native of the West Indies, has made its appearance in a fairly large quantity in the above district. It had probably originated by wind-born spores from the garden of Mr. A. Agnew close by It may be classed as an exotic not sufficiently established to be considered naturalised.

SURIANA MARITIMA, L (Simarubaceae)

Goldburn Island, Northern Territory, M Holtz, No. 22, March, 1911.

This plant is a low bushy shrub, 4 to 6 ft. high, growing at high water mark on the Island. Flowers yellow.

[Proc. Roy. Soc. Victoria, 33 (N.S.), 1921.]

Art XV.—*The Estimation of Acidity.*

By J. M. LEWIS, D.D.Sc., Melb.

(Communicated by Professor W A. Osborne, M B, B Ch, D Sc)

[Read 9th December, 1920]

Three methods are in practice available for the determination of the acidity or basicity of solutions, i e, their hydrogen ion concentration :—

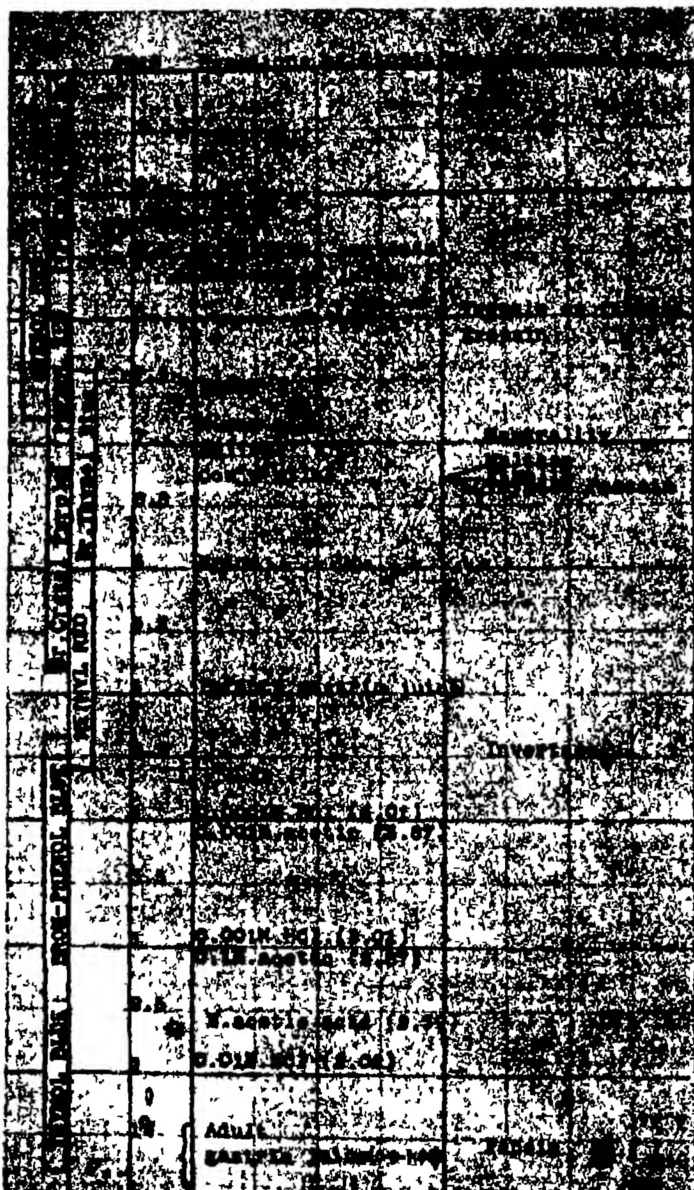
(1) The use of a "ladder" of indicators
(2) The hydrolysis of esters
(3) The electrometric method.

(1) The employment of a "ladder" of "Indicators" which give definite color changes at different hydrogen ion concentration.

These properties, which are possessed by many of the aniline dyes, have been employed by Salm and Sorensen in arranging a scheme which makes use of about fourteen of these substances, the authors mentioned having placed them in a table, showing the indicators available, and the concentrations which their colour changes cover. This table, which has been altered and improved by Bayliss, will be found in his "Principles of General Physiology," (1), and the student is recommended to examine it. On inspection it will be seen that as many as four changes of hydrogen ion concentration may be made apparent with one indicator, and these are so arranged that there is a definite gradation in the series, from high, i.e acid, concentrations, through neutrality, to the low concentrations of alkaline solutions, which, in spite of the seeming paradox, possess a demonstrable hydrogen ion concentration.

By means of these indicators, concentrations ranging from $N \times 2$ to $N \times 10^{-12}$, may be measured and some idea of the principles involved in the arrangement of the "ladder" may be gained when it is pointed out that, whereas crystal violet in solution becomes golden yellow at a hydrogen ion concentration of

at Nx10^{-2}, and violet at Nx10^{-3}; undergoing no further change Nx2, it becomes grêen at one of Nx1, green blue at Nx10^{-1}, blue in decreasing concentrations. Again, phenol-phthalein is colourless in hydrogen ion concentrations, ranging from Nx2 to Nx10^{-8}, but it becomes rose coloured at Nx10^{-9}, red at Nx10^{-10}, and thereafter remains unaltered.



It will thus be seen that by the selection of a suitable indicator sensitive over changes of hydrogen ion concentration which may be anticipated, accurate information as to the ionic concentration of an unknown solution may be gained

A "ladder" of indicators arranged by the writer, somewhat on the lines of that in S. W. Cole's Practical Physiological Chemistry, 5th edition, is illustrated in figure 1. The dyes there mentioned are prepared by the Cooper Laboratory, Watford, who reproduce the scheme referred to.

If this "ladder" be examined, it will be seen that the indicators there shown cover a wide range of possible hydrogen ion concentration, and it may be of interest to note certain of the features of some of the indicators in this particular series.

Methyl red and thymol blue, for instance, may be used in the precipitation of an amphoteric substance, such as anthranilic acid from its alkaline solution In this operation, insufficient mineral acid will not completely precipitate the organic acid, while an excess will redissolve it. By the use of these indicators the exact point is readily found To do this one employs a test paper saturated with methyl red, making spot tests upon it from time to time, until the acid point is approached; then the addition of acid is further continued until a thymol blue paper also shows an acid reaction, which is the concentration of acid at which the maximum precipitation takes place. In thymol blue we have an indicator of two useful working ranges, i e, an acid and an alkaline range, which can be employed in differential acidimetric and alkalimetric titrations Any acid with a dissociation constant equal to or less than acetic acid, can be titrated in the presence of hydrochloric acid if the weaker acid is completely neutralised when the alkaline change of indicator occurs (2)

One illustration taken from a communication by Clark and Lubs will serve to show the application of this method to the differential titration of an organic acid in the presence of hydrochloric acid.

Many organic acids are not dissociated at a concentration of hydrogen ions at which hydrochloric acid is itself completely dissociated. If to a saturated aqueous solution of benzoic acid a known amount of indicator be added, and this is used as an indicator colour standard, the hydrochloric acid content of an unknown mixture may be estimated by titration with normal sodium hydroxide, in the presence of the same indicator, until the colours are matched. Care must be taken that the indicator

concentration in the two solutions is identical. The most suitable concentration of thymolsulphonephthalein will give the solutions a pale yellow colour. The titration is continued until the first trace of blue in the alkali range is reached. At this point all the benzoic acid has been neutralised. In carrying out such a measurement it is most important that equal amounts of indicator be added to both solutions, that the final volumes are the same, and the colour matching be carried out in daylight of uniform quality. (3)

The colorimetric method is however restricted in its scope. Generally speaking it cannot be used with coloured solutions, and furthermore, the personal element must always enter largely into any scheme which involves a nice discrimination between slightly varying shades of colour.

(2) The Hydrolysis of Esters.

This depends upon the fact that the hydrolysis of methyl and ethyl acetic esters is, in strong concentrations of hydrogen ions, proportional to that concentration

For example, when methyl ester is acted upon by water in considerable dilution, the conversion to alcohol and acid is practically complete, thus:—

$$CH_3.COOCH_3 + H_2O = CH_3.COOH + CH_3OH.$$

The technique of the method consists in the titration of the acid-water-ester mixture at intervals against a N/20 baryta solution in order to ascertain the end point of the reaction The flask containing the mixture must be immersed in a thermostat.

A water-ester mixture under identical conditions is kept under observation as a control, and the calculation of the result is based on Guldberg and Waage's formula for the velocity of chemical reaction. (4) The method must be regarded as more or less cumbersome, and since the final result cannot be ascertained until the reacting solutions have remained in the thermostat for 48 hours, it may be set aside as not fulfilling the necessary requirements for routine use in the laboratory.

(3) The Electrometric method.

This method of estimating the actual hydrogen ion concentration of a given solution is that which, in spite of certain difficulties in the way of a rigid technique, must be regarded as the final court of appeal in any investigation which has for its object the estima-

tion of hydrogen ion concentration. Its sensitiveness is remarkable, and this will perhaps be better realised when it is pointed out that its use has made possible as an ordinary laboratory procedure the estimation of the change in the hydrogen ion concentration in the blood, which controls the mechanism of respiration. (5)

The method is free from the objections inseparable from the use of colorimetric methods, and it may be used to determine with great exactitude the end point in a titration, where a definite cencentration of hydrogen ions is aimed at. Furthermore, since no reagents are introduced, the solution undergoing investigation remains the same at the end of the examination as at the beginning.

In comparing the electrometric with the colorimetric method this very important fact must be kept in mind—titration methods exhibit the total amount of acid or alkali present, i.e. dissociated, plus undissociated, since with every addition of standard acid or alkali chemical combination takes place, and a further portion of the dissolved substance becomes dissociated. This process will continue until the whole of the reacting acid or base is neutralised, and thus, not the actual, but the available amount of reacting salt is shown.

The routine use of such an exact method has become a necessity to the biochemical worker. To take a case in point, one of the notable advances in both human and comparative physiology has been the recognition of the great importance which attaches to the maintenance of the blood at an hydrogen ion concentration, which varies only within the narrowest limits In the blood, an elaborate mechanism, involving the "buffer" action of its contained carbonates and phosphates exists for this purpose. As Bayliss points out, in the case of the frog, "the heart is affected by so small a change in hydrogen ion concentration as that from neutrality, $Hx10^{-7.7}$, to one of $Hx10^{-6.5}$, while a rise in H. concentration corresponding to that effected by adding 0.036 mgm. of HCl to a litre of distilled water, i e., to $Hx10^{-6}$, is fatal."

To quote Bayliss's words, "If we were dealing with distilled water only, the addition of one-millionth of a gram molecule of HCl to a litre of distilled water would raise its hydrogen ion concentration from $Hx10^{-7}$ to $Hx10^{-6.5}$, and such a change as this represents would be ten times in excess of that which would be fatal to many protoplasmic processes."(1)

The electrometric method is of service in investigations involving the optimum reaction of enzymes.

Recently its application to the preparation of bacteriological media having a prearranged exact hydrogen ion concentration has proved to be of the greatest utility. Beside this, the investigation of the acidity of soil extracts, which is now known to bear an important relation to plant growth, has been shown to be another field in which the method should be of great use.(6)

In the presence of these facts it will be evident that an instrument of precision for the measurement of such slight variations in hydrogen ion concentration is of the greatest value to the biological chemist, and it is safe to assume that the hydrogen electrode will also occupy an important place in the clinical armamentarium of the future.

Theory of Electrode Potential.

Before proceeding to a description of the hydrogen electrode in detail, it will be necessary to discuss in general the principles which underlie its use. The practical application of the method received a great impulse from the work of Nernst, who showed that when a metal made contact with a solution of one of its salts, the electric charge, or potential, which it acquires with respect to the solution, bears a constant relation to the concentration of the dissolved salt.

As this law holds good whatever the salt may be, it is evident that the e.m.f. developed depends only upon the concentration in the solution of ions identical with the metal employed (7)

When any substance goes into solution—and all substances exhibit a certain tendency to dissolve—we must conceive the process to be accompanied by electrical phenomena.

In the case of a soluble salt, its solution will be followed instantly by the dissociation of a certain fraction into ions bearing complementary charges of electricity. As such a system is in a state of equilibrium, the electrical phenomena are not manifest.

Where metals are concerned, however, the case is different, since a metal, when dissolving, can only give off to the solution positively charged ions, and, depending on the degree to which it does so, the metal will become negatively charged.

We may take a concrete case. Let us suppose a rod of zinc to make contact with a solution of the chloride of this metal. Two opposing forces now come into operation. One is represented by a tendency of the zinc rod to go into solution, and become to this extent negatively charged, i.e., to give off posi-

tively charged ions to the solution. The other is a tendency for the dissociated zinc to abandon the ionic form, and to appear upon the rod in the metallic state; but while this latter will be recognised as the osmotic pressure of the dissolved metal, the former has been termed by Nernst the "electrolytic solution pressure" of the metal in question.

It will be evident then, that where the osmotic pressure of the dissolved salt exceeds the electrolytic solution pressure of the metal, the plus charges imparted in this way to the rod will cause it to become positively charged with respect to the solution.

It must be understood that owing to electrostatic attraction, the plus charged ions cannot move more than an infinitesimally small distance from the rod unless an external circuit be provided, when a current will pass until equilibrium is established. Until the external circuit is closed we must assume the existence of a "Helmholtz double layer."

We may perhaps make the matter clearer and trace a closer correspondence between theory and practice by studying the development of an e.m.f. in such a cell as the Daniell.

The Daniell cell consists of a glass vessel, within which is placed a porous cylinder.

The outer vessel contains a solution of copper sulphate in which is immersed a copper plate, while the inner vessel is supplied with a solution of zinc sulphate in which rests an electrode of zinc.

If electrical connection be made between the zinc and the copper plate, a current will follow, and a galvanometer inserted in the circuit will indicate an e.m.f of 1.1 volt

The production of this e.m.f. may be explained thus:—

Copper exhibits in solution a strong tendency to abandon the ionic form, and its electrolytic solution pressure is therefore low, being lower than its osmotic pressure. In consequence of this a copper electrode is positive to solutions of its salts.

On the other hand, as we have seen, the zinc readily gives off positively charged ions to its solution, and its charge is therefore negative.

The combination in the Daniell cell, i.e., copper—copper sulphate; zinc—zinc sulphate, may be represented graphically thus:

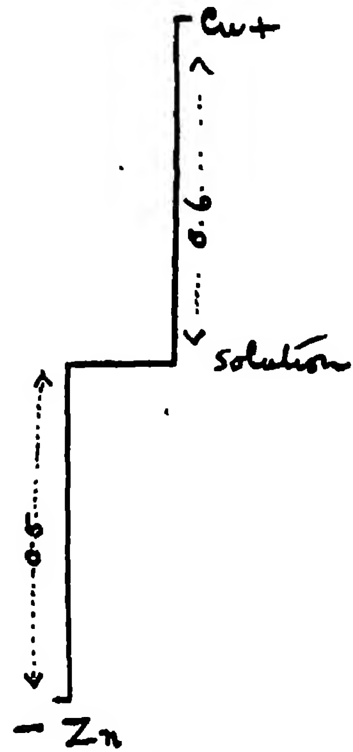


FIG 2 (After Lehfeldt)

The sum of the differences thus shown is 1 1 volt, which is the known voltage of the Daniell cell

Concentration Battery

Knowing the laws which govern the production of e m.f. it is possible to set up an arrangement known as a "concentration cell," in which both electrodes consist of the same metal. These are made to dip into vessels containing a solution of a salt of the metal at differing concentrations. Electrical connection is made between the vessels by suitable means. The arrangement shown below may be employed, where a suitably bent glass tube contains the solutions, means being employed at *c* to prevent rapid diffusion. Let the electrodes at *a*, and *b*, for example, consist of silver, and the solutions be of some salt of that metal.

If, now, the electrodes be connected with a galvanometer, an e.m.f. will become apparent, which, as far as the external circuit is concerned, is directed toward that electrode which dips into the more dilute solution.

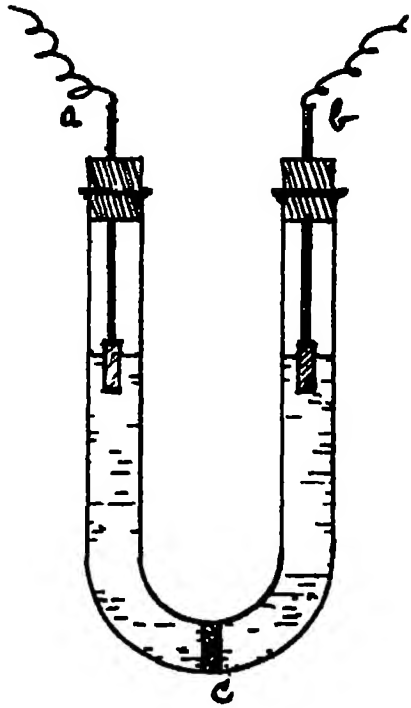


FIG 3

The production of an e m f in this case and its direction depend upon the fact that while both electrodes give off positively charged ions to the solution and to this extent become negatively charged themselves the electrode which is in contact with the more dilute solution is freer to do so on account of the lower osmotic pressure of the ions already in solution For this reason it must become negatively charged to a greater degree and the electric equilibrium having been upset an e m f is shown by the galvanometer

Hitherto we have dealt with the production of e m f when metals make contact with solutions of their salts but an e m f is similarly produced where certain gaseous elements make contact with aqueous solutions containing the same element in an ionised state This may be demonstrated in the case of oxygen in contact with an alkaline solution i e one containing dissociated OH but for certain technical reasons a more general application has been found for a method in which hydrogen is brought into

contact with solutions containing hydrogen ions, using this as a criterion of their comparative acidity.

In order to demonstrate this, advantage is taken of the property of condensing gases possessed by "platinum black," and the metal deposited in this form upon platinum or gold constitutes the electrode

When such an electrode is placed in an atmosphere of hydrogen, the condensation of the gas on its surface is of such an order that the arrangement may be regarded as a solid rod of hydrogen, and, with certain technical restrictions, used as if it were such.

We may show the production of an e.m f. with this electrode by setting up an arrangement similar to that described as a "concentration battery," only in this case means must be provided for keeping the platinum black saturated with hydrogen, while the two electrodes dip into solutions of an acid which differ in concentration from each other. A diagrammatic view of the apparatus is shown in Fig. 4.

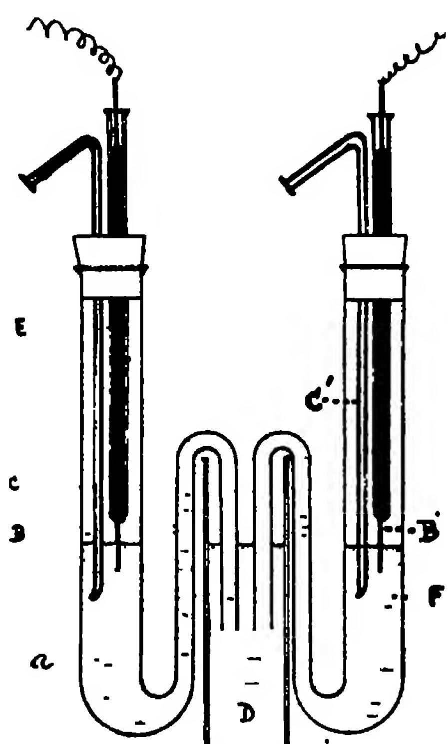


Fig 4.

Let A be a vessel containing acid of known concentration, N/10 HCl for example, whose H ion concentration is known, while F represents a similar vessel containing acid of unknown strength. Dipping into the acid are two "hydrogen electrodes," B, B′, and means are provided whereby hydrogen is bubbled through the acid by means of the fine tubes CC′, creating an atmosphere of this gas about the exposed surfaces of the electrodes. The hydrogen is at atmospheric pressure, and serves to keep the electrodes in a state of saturation. Bent tubes from each electrode vessel make contact with a saturated solution of potassium chloride in the vessel D (the reason for which will be explained later), and wires from the electrodes complete a circuit which includes a delicate galvanometer.

On closing the circuit a current will flow in the direction of the vessel containing the weaker acid, since, in this case, the electrolytic solution pressure of hydrogen is greater on the electrode which is in contact with the acid of lesser concentration, i.e. of lesser hydrogen ion concentration. Thus, the electrical balance is upset, this electrode having a lower potential than that in the vessel containing the stronger acid Such an arrangement is termed a "gas chain."

Nernst conceived the idea that these electrical phenomena might be treated quantitively, and he was able to construct a formula by which the hydrogen ion concentration of the unknown solution might be calculated, provided the e.m.f developed, and the hydrogen ion concentration of the other solution were known.

In developing this formula Nernst was able to utilise the work of van't Hoff, who showed that if osmotic pressure be substituted for gas pressure in the formula $pv - RT$, the "gas laws" are applicable to substances in solution. Their assimilation may be shown in the following way: Consider the case of a metal in contact with a solution of one of its salts, and call the "electrolytic solution pressure" of the metal P, and the osmotic pressure of the dissolved salt p; then the dissolved metal as it gives off ions may be regarded as going from pressure P to pressure p. Now, when a gram molecular weight of a gas expands isothermally from a pressure p_1 to another p_2, the amount of work done A, is expressed by the formula $A = RT \ln P_1/p_2$ where R is the gas constant, and T the absolute temperature. Similarly, where a formula weight in grams of metal in dissolving and dissociating into ions, goes from solution pressure P to an osmotic pressure p, the maximum work is shown by the formula, $A = RT \ln P/p$

If an equivalent weight of an univalent metal goes into solution, the charge carried by the ions will be 96540 coulombs, i.e., the Faraday constant F. However, total electricity is equal to quantity multiplied by intensity or potential; the formula will therefore be) $P = RT\ 1n\ P/p$ or $P = RT/F\ 1n\ P/p$. Where the metal is not univalent, but has the valence n, this factor is introduced thus: $P = RT/nF\ 1n\ P/p$. (8). Now R, in electrical units, is 8.3 joules per degree, and F, in coulombs, 96540, while the absolute temperature T, is 291 (273 plus 18). The formula RT/F thus becomes:

$$\frac{8{\cdot}3 \times 291 \times 2\ 3}{96540} = 0\ 058v$$

The modulus 2.3 is introduced in order to bring natural to common logarithms.(9)

The significance of this equation is that a ten-fold change in the concentration would cause a difference of 0.058 v in the electrode potential for a univalent ion, 0.029 for a bivalent, and 0.193 for a tervalent, and it certainly holds good for solution *below* decinormal strength. (10) The practical application of this will be considered later.

The e.m.f. developed by the hydrogen electrode varies within fairly narrow limits, and is never greater than a fraction over one volt. For the measurement of such currents where extreme accuracy is not called for, as in determining the end point of a reaction, or checking the normality of solutions used in volumetric analysis, a sensitive galvanometer may be used as described by Hildebrandt. (11)

In biochemical work, however, the standard practice is to employ the Poggendorf compensation method, using a potentiometer for this purpose.

In its simplest form (shown diagramatically in Fig. 5), the apparatus consists of a wire, *a, b.* of uniform calibre, stretched along a wooden "metre stick." To this wire a steady e.m.f. of about 1.5 volt is applied by means of an accumulator C. If now a cell D, whose e.m f. it is desired to measure, be so connected to *ab,* that its e.m.f. is opposed to that of the cell C, and is supplied with a movable contact which slides along *ab,* then a point may be found where no deflection takes place in the galvanometer E, which is inserted in the circuit.

When this point is found, then the e.m.f. of the cell D is equal to the potential drop along AF, and it therefore corresponds to the ratio AF.FB.

In practice the potentiometer is constructed in such a way that a variable resistance is introduced between the accumulator C, and AB, the wire AB (or what corresponds to it) being placed against a scale which is graduated from zero to 1 5 volt. Instead of an unknown e m f. at D, a standard cell such as the Weston

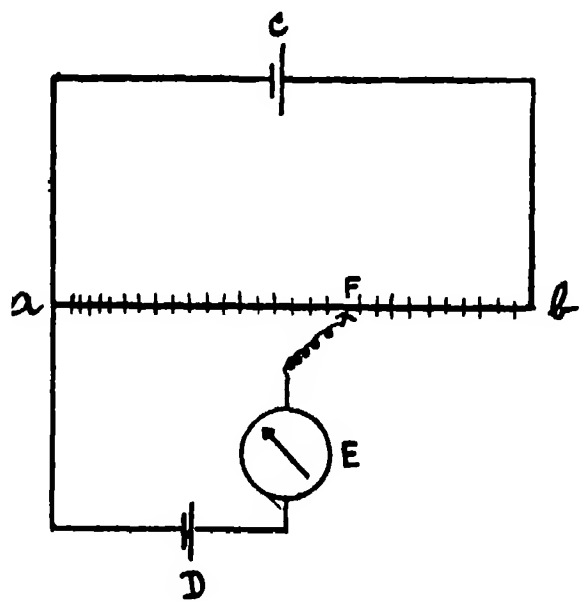


Fig 5

element is introduced, the movable contact F being placed on AB, at the known voltage of the cell used When this is done, the variable resistance is adjusted until no deflection of the galvanometer E takes place. If now the source of current C be developing a steady e m f, the potential drop along the wire AB will correspond to the divisions on the scale, and the instrument will be ready for the determination of the unknown e.m.f. required.

To do this, the standard cell is cut out by means of suitable switches, and the source of the unknown e m f. (which may be a cell, or in this instance, the hydrogen electrode-calomel electrode used in these investigations) is thrown into the circuit. The sliding contact is now moved along AB until no deflection of the galvanometer occurs, and the required e.m f. may be then read off on the scale.

In the concentration chain, and also in the gas chain previously referred to, an e.m.f. was shown to develop when electrodes were in contact with solutions which differed in the concentrations of the particular ion concerned, the two solutions being made part of an electric circuit.

In practice it would be possible to measure the H ion concentration of an unknown fluid, using for one side of the "chain" a solution of unit H ion concentration, i.e., corresponding to one gram ion per litre (12).

In the case of hydrogen, however, there is "much uncertainty in the reduction to normal ionic concentration," (10) and in routine work other means of completing the "cell" must be sought.

It will have become obvious that the hydrogen electrode which dips into the unknown fluid constitutes but one-half of the galvanic cell which must be constructed in order to determine the e.m.f. It is therefore necessary to complete the system by introducing as the other half, an electrode which develops a constant e.m.f. For this purpose the standard practice is to employ a "calomel electrode." For a full description of its preparation - text-book on the subject may be consulted.

It will be sufficient here to remark that these electrodes are named from the normality of the potassium chloride solutions used in them The decinormal electrode has been very generally employed for this purpose, but the saturated calomel electrode has the advantage of easy preparation, and the absence of any need of a temperature correction. The latter has been almost exclusively employed by the writer, and has been found to meet all requirements Its construction has followed the form suggested by Barendrecht. (13)

The materials used in making these electrodes have to be of extreme purity, and in connection with this, reference should be made to Findlay, (14) the classic article by Loomis and Acree (15), and the recent text book by W M Clark. (23)

As the e.m.f. of a calomel electrode varies with the concentration of the KCl solution employed, it is necessary to record on the electrode vessel the normality of the solution. For future reference it may be noted that the e.m.f. of a *hydrogen electrode* when the hydrogen ion concentration of the solution is normal, and when a saturated KCl electrode is employed, is 0.251 volt, whilst with the deci-normal KCl it is 0.3377 volt.

Some writers consider the potential of the calomel electrode as zero but it is perhaps more convenient to call the normal hydrogen electrode zero and then say that the potential of the calomel electrode is 0 251 volt or whatever the figure may be

A convenient form of calomel electrode suggested by Barendrecht is shown in fig 6 where *d* is a glass jar closed by a double bored rubber stopper containing a saturated solution of potassium chloride A test tube *c* perforated a short distance from the bottom contains a small quantity of pure mercury Dipping below the surface of this a glass tube *b* provided with a sealed platinum wire enables one to effect electrical connection through a fine column of mercury contained in it The glass tube *e* serves to connect the cell with a vessel containing saturated KCl The stopcock *g* provided it is not greased may be kept closed during measurements At *f* a plug of cotton wool prevents diffusion into *e*

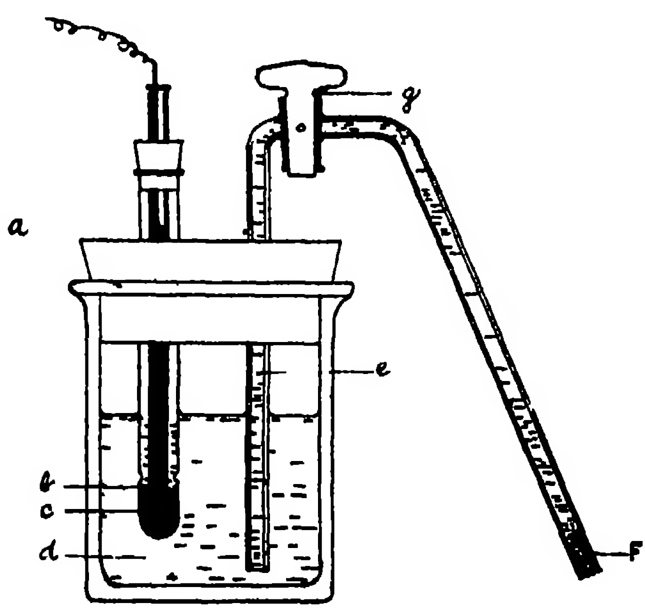


Fig 6

The connecting fluid

For obvious reasons it is impossible to connect the calomel and hydrogen electrodes electrically by means of a metallic conductor The usual practice is therefore to allow both electrodes to dip into some conducting solution The proper selection of this

solution is a matter of great importance since serious errors would be introduced if reaction occurred between it and that in the electrodes. Some error is inevitable where solutions which are not identical are in contact, and in work which necessitates extreme accuracy, due allowance is made for this, but for routine biochemical estimations "contact potential" may be ignored. This has been made possible by the use of a saturated solution of KCl as a connecting fluid. In such a solution the speed of the dissociated ions is equal or nearly so; furthermore, where the saturated calomel electrode is employed, the solution is identical with that of the electrode, in which case error can occur only at the point where the fluid in the hydrogen electrode comes into contact with the connecting solution. For more detailed information the student is referred to the article by Michaelis. (7)

The Hydrogen Electrode.

The hydrogen electrode consists of a small element of pure platinum, or sometimes gold, which has had a layer of "platinum black" deposited upon it, and great care must be taken that the electrode is at all times completely platinised, and is not contaminated. The form given to the electrode varies according to the choice of the worker; thus it may be a small rectangular piece of foil, as used by Hildebrand (10) and Clark (16), or again it may be simply a fine platinum wire, the form preferred by Walpole (17) and Barendrecht (13). Under any circumstances, the electrode, when saturated with pure hydrogen, is placed in the solution in such a way that while part of it is immersed, a considerable portion is still exposed to the gas. Willsmore carried out his measurements with a rectangular piece of foil, which dipped for a considerable distance into the solution (19). It has been shown, however, that a steady e.m.f. is obtained more quickly when there is a minimum contact between the electrode and the solution. The reason for this is not at once apparent, but it is supposed to depend on certain peculiar physical conditions at the surface of the liquid, whereby a rapid diffusion from the surrounding solution to the point of contact is prevented, the local conditions maintaining an equilibrium, which is not quickly upset (16). As minimum contact is easily obtained with the electrode devised by Walpole, this electrode, modified by Barendrecht, has been most

generally used in this laboratory It has been shown by Hasselbalch that a steady e m f is rapidly obtained when the electrode vessel is shaken, thus bringing all the solution into contact with the electrode, and he has devised special apparatus for doing this (20) The Hasselbalch electrode has undergone some modification at the hands of other workers, and of these, that constructed by Clark has found general acceptance A full description of the electrode will be found in the article by Clark (16)

Hydrogen Electrode

The Barendrecht electrode consists of a capillary glass tube, having an elongated bulb of about 0 5 c c capacity blown upon it A platinum wire is sealed in through the side of the bulb, and bending at right angles approaches the constriction in the lower part This is shown in Fig 7

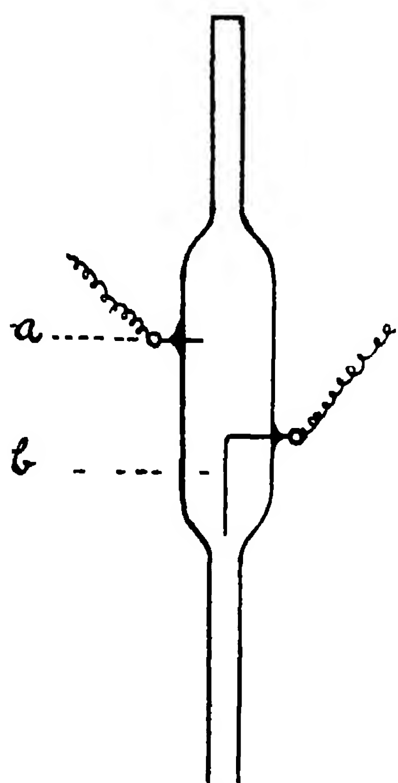


Fig 7

The platinum wire at B has a fine copper wire soldered to it, which is led away to a potentiometer. In experimenting with the electrode, the writer was led to make several modifications in its construction. In the first place, it was found that in platinising the electrode, the resistance of the solution in the fine part of the tube was a disadvantage. To obviate this, the writer sealed what may be termed an "inert electrode" into the tube at A. This is used only during platinising, constituting the anode in the system, and the arrangement, when used with a platinising vessel, to be described later, makes for convenience and ease of operation.

Another modified electrode is shown in Figure 8, which, in this case is provided with two hydrogen electrodes, and one inert electrode. It is thus possible to compare the e.m.f.'s of two electrodes simultaneously placed in the solution under examination, and with it one learns how easily an incorrect reading may be given by an electrode which, to all appearances, is properly platinised, and is in good working order.

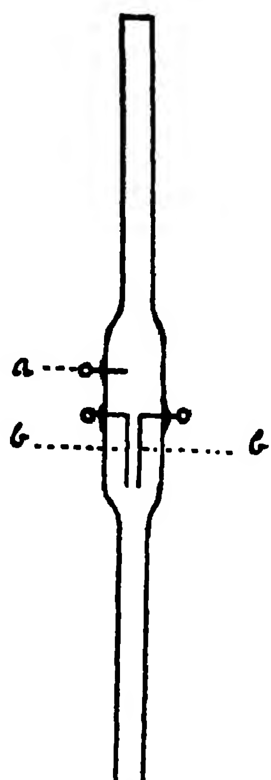


Fig 8.

The Platinizing of the Electrodes

The platinum electrodes for hydrogen ion estimation which have just been described are coated with platinum black in the following manner

First the platinum is thoroughly cleared from grease and other foreign matter by immersion in a potassium bichromate sulphuric acid mixture It is then washed and connected to the negative pole of an accumulator or suitable source of current If the electrode is of the removable type such as the Walpole Hasselbalch or the Clark it is now placed in a beaker and covered with the platinising solution the current from the positive side being led into the solution by a clean platinum wire The platinising solution must be prepared with due precautions as to its chemical purity and consists of a 3 per cent solution of platinic chloride with a trace of lead acetate added to it A new electrode will require to be immersed possibly for five minutes and some operators suggest the coating should be so thick that part will fall off When the electrode is completely coated with platinum black it must be well washed after which it is again connected to the cell and made the negative electrode in a beaker containing dilute sulphuric acid a platinum wire as before constitutes the anode The current should be sufficient to cause vigorous bubbling By this means all traces of platinum chloride will be removed from the coating on the electrode (7) It must now be well washed in a stream of distilled or preferably conductivity water and afterwards kept in a beaker of the same from contamination Prolonged washing of the electrode is not necessary after this treatment The writer has devised an arrangement which makes the platinizing of the Barendrecht or modified Barendrecht type of electrode comparatively simple

It is illustrated in figure (9) where *e* is a vessel closed by a double bored cork *a* is the electrode tube while to *d* a rubber tube is connected which is kept closed with a clamp In using the apparatus one blows through *d* and forces the level of the platinising solution above the electrodes in *a* As the electrode tube is thus kept vertical during platinisation the bubbles of gas coming away from the electrodes are free to escape at the upper end of the tube With other methods of coating this bubbling about the electrodes was a great source of trouble An exactly similar glass vessel is provided to which the electrode is trans-

ferred, subsequent to its platinising, and after a thorough washing in distilled water.

The second vessel is provided with a 5 per cent. solution of sulphuric acid, and when the electrodes have been connected

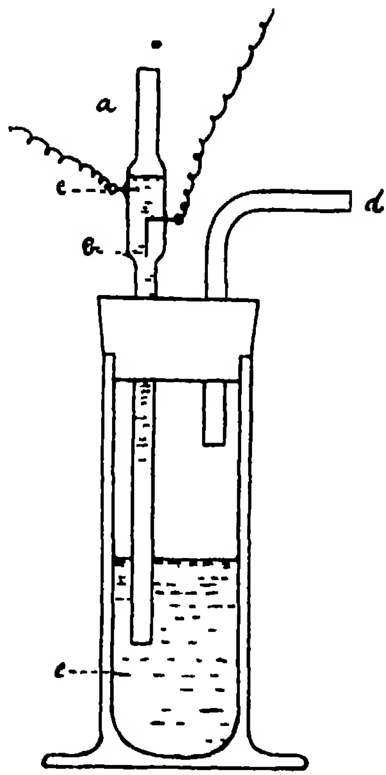


FIG 9

as before, i e., making the hydrogen electrode negative in the arrangement, it is left to bubble vigorously for about ten minutes. It must now receive a most careful washing, and after saturation with hydrogen, be preserved in a beaker of distilled water.

As Michaelis points out, the hydrogen electrode does not need replatinising frequently when protein solutions only are used.

It does not readily make small errors, but if out of order will give quite impossible results. A deterioration of the electrode is indicated when it takes a long time to obtain a constant reading. In taking readings Michaelis recommends that they should be made every ten minutes, and should not be accepted until three successive readings are identical. Before

use in routine investigations, the hydrogen electrode must be subjected to a test in order to ascertain if it be in good working order. To do this one must place in the electrode vessel a solution of known hydrogen ion concentration, and for this purpose Michaelis suggests a "buffer" mixture made as follows:—

10 c c N Na OH
20 c c. N HA.
70 c c distilled water.

Using the N/10 KCL calomel electrode this mixture should, at 18°C. give an e.m f of 0.6045 v. At other temperatures the e.m.f. of this chain is as follows:—

20 c	0 6061 v.
22 c.	0 6078 v.
24 c.	0.6093 v.

That is to say, there is a rise of 0 8 millivolt for every degree of temperature. (7)

Examination of Fluids Containing Gases in Solution.

The presence of such gases as oxygen, chlorine, ammonia, carbon dioxide or nitrogen in solutions makes their examination by the electrometric method difficult, or in certain cases, impossible.

Chlorine gas in such a fluid for instance, would partly saturate the electrode, and also diffuse into the gas space above In this case, the e.m.f. would be in part due to its presence, thus making the result worthless from the point of view of hydrogen ion concentration estimation.

Ammonia is a gas, the presence of which makes an examination by this method impossible.

The occurrence of CO_2 in solution is common enough in physiological fluids, and it is of some importance that the effect of its presence on the e.m f. developed be noted. The diffusion of CO_2 into the gas space above the fluid will lower the partial pressure of the hydrogen, and as the electrolytic solution pressure of hydrogen is a function of its partial pressure, the reading on the potentiometer would not be an accurate measure of the hydrogen ion concentration of the solution. As to whether the error thus introduced is sufficient to be of importance, authorities differ. Milroy, in carrying out some important investi-

gations in the changes of hydrogen ion concentration in the blood, was content to disregard it. He remarks that the error must be small, since the measured e.m.f. varies only as the logarithm of the partial pressure, and in his opinion its recognition did not warrant the needless bleeding of the animal involved in the method of Hasselbalch (5).

Where it is thought absolutely necessary to eliminate this source of error, recourse may be had to the Konikoff or Hasselbalch electrode vessel.

These vessels provide means whereby the specimen being examined may be brought into contact with the hydrogen atmosphere above the electrode and shaken, thus allowing the tension of the CO_2 in the hydrogen to become equal to that in the fluid. After this has been done, the fluid is removed, and replaced by a fresh sample without changing the hydrogen atmosphere. There will then be no further diffusion of CO_2 into the gas space, since conditions of equal tension will have been established as regards any CO_2 present Incidentally, the shaking of the electrode tube will have the effect of removing any oxygen present in the liquid, by combining it with the hydrogen of the electrode. This in itself will assist in obtaining a constant e m f in a comparatively short time.

Preparation of the Hydrogen.

The hydrogen used in these tests must be of extreme purity. If it be prepared from dilute sulphuric acid and zinc in Kipp's apparatus, there may be some danger of contamination with hydrogen sulphide Michaelis suggests that the gas be washed with potassium permanganate solution, to remove any oxidisable substance, and then bubbled through a solution of mercuric chloride (7)

Sharp and Hoagland prepare the hydrogen by electrolysing a 25 per cent by weight solution of caustic potash in a special cell, using nickel electrodes. The hydrogen is led away, and passed through a tube containing platinum black deposited upon asbestos, which is kept hot by means of a glowing spiral of high resistance wire electrically heated, the purpose of which is to remove, as water, any oxygen which might be present. (6)

In this laboratory, hydrogen, electrolytically prepared, and stored in steel cylinders, is exclusively employed for saturating the electrodes.

The Operation of the Electrode.

As has previously been remarked, in this laboratory, the simple electrode devised by Barendrecht has been used to the exclusion of all others in routine work. In Barendrecht's original article it will be seen that the fluid is drawn up and down the glass vessel by a close fitting syringe. This is shown in Fig. 10. To

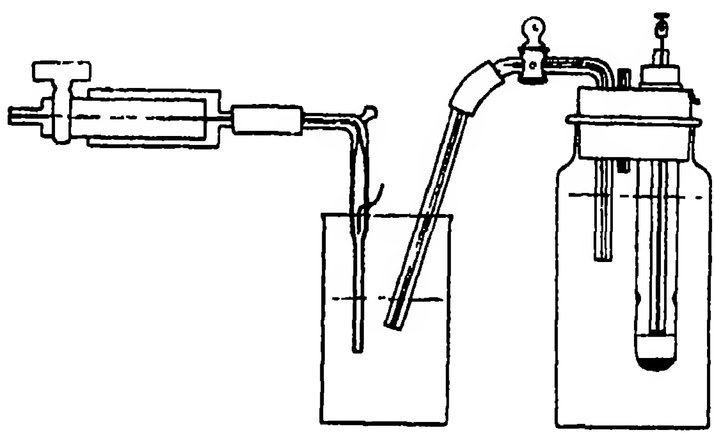


FIG. 10. After Barendrecht

do this by hand in the usual way made it difficult at times to affect the fine adjustment needed to obtain a minimum contact. The writer has therefore devised a ratchet and pinion attachment, which is connected to the plunger of the syringe, which allows a very exact adjustment to be made with but little trouble.

A diagramatic view of the device is shown in fig. 11, where *a* is the "syringe," and *b* the perforated plunger, which is controlled through the rackwork by means of the milled wheel *g*. The hydrogen is admitted at *c*, and the glass electrode tube *e* is attached closely to the apparatus by a rubber tube *d*. The whole arrangement is made adjustable on the stand *f*.

The technique of using this apparatus is as follows:—Having thoroughly ventilated the electrode with hydrogen, and before the fluid to be investigated has been drawn up the tube, the plunger should be moved in and out by means of the milled wheel in order to remove any trace of air which might be occluded between it and the end of the tube; then, with the hydrogen passing through the electrode slowly, the open end of the glass tube is brought below the surface of the liquid to be

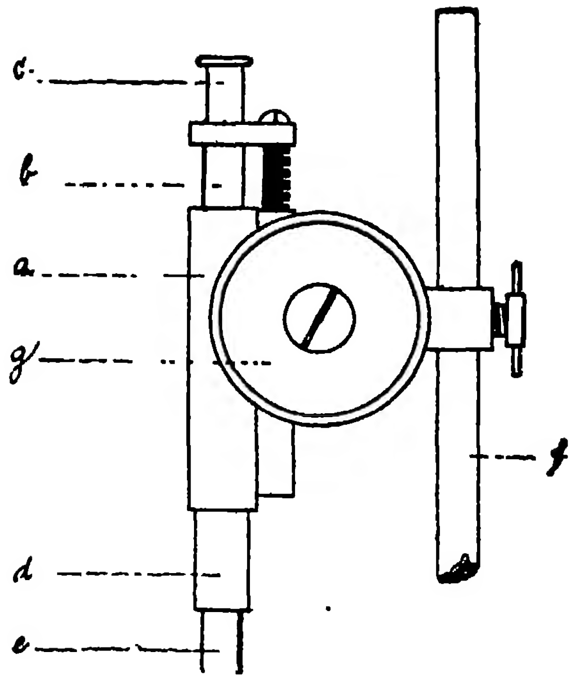


FIG 11

examined. Immediately this is done, the gas should be cut off, the cock on the piston being provided for this purpose The piston is then gently drawn out of the barrel, and the solution allowed to enter the vessel, and completely to cover the platinum wire. Keeping the end of the vessel still below the surface of the liquid, the contained fluid is ejected from the tube, allowing a minute portion to remain in the capillary end. Another portion is now drawn up and down the platinum wire, and again ejected, after which the final portion is allowed to enter the vessel in such a manner that the platinum wire makes a minimum contact with the fluid In dealing with liquids which do not contain carbon dioxide, it is not perhaps so necessary to leave a small quantity in the tube as described, since the object of this is to retain the original hydrogen atmosphere, plus carbon dioxide in equilibrium with that contained in the fluid. The reason for "washing" the platinised wire with the fluid of the final portion is, that in this way the contained oxygen is reduced by the hydrogen of the wire, and a steady e m f. is sooner obtained, also the changing of the solution should enable the CO_2 in the final portion to be in equilibrium with that in the hydrogen, and thus do way with any risk of diffusion from

fluid into gas space The electrode tube is now wiped with filter paper in order to remove any fluid adhering to it and the vessel containing the connection solution is brought below it the tube making minimal contact with the solution The tube connected with the calomel electrode having also been brought below the surface of the connecting fluid the operator may now proceed to measure the resultant e m f according to the directions supplied with the particular potentiometer used

In recording these measurements a note should be made of the time elapsing between each test a convenient interval being five minutes In general it will be noticed that during the first few minutes there will be a gradual increase in the e m f This effect is less noticeable with those electrodes which employ a shaking device and if such be used it would appear to be desirable to depend upon measurements taken a short time after the preliminary shaking rather than upon the record of a single long experiment This matter of potential drift is treated at length in the article by Clark previously referred to

Between each experiment the electrode tube must be thoroughly washed with distilled water it should be then saturated with hydrogen and immersed in a beaker of distilled water in which it is kept until required

The Calculation of the Result

Having obtained the e m f on the potentiometer scale the H ion concentration is calculated from it by means of Nernst s formula as follows to quote Milroy —

Let π_1 = the e m f of the system

π — the e m f of the calomel electrode employed when the H concentration is normal viz 0 251 volt at 18 C using the saturated KCl calomel electrode while C and C_0 are the H ion concentrations of the two fluids

Then—
$$\pi_p = \pi + 0577 \log \frac{Co}{C_p}$$

C may therefore be calculated when π is measured

Or if P be substituted for Cp ($10^{\;p}$) the result may be made to serve as a basis of measurement

So then—
$$\frac{\pi_p \quad 251}{0577} = \log \frac{1}{C} \text{ or } -\log C$$

The value $-\log$ C is, in accordance with the suggestion of Sörensen commonly employed to express the H ion concentra

tion, and has received the name " Sorenson's negative hydrogen ion exponent," and is indicated by the sign P_H, or pH.

In dealing with such a notation, one must bear in mind the fact that a rise in the P_H signifies a fall in the H· ion concentration. (5) As Baylis remarks, while it is "easy to see that a hydrogen ion concentration of 4×10^{-6} is double that of 2×10^{-6}, it is not at once obvious that a P_H of 5.398 is double that of 5.699. One has to get accustomed to thinking in negative logarithms." (1)

To this end it may perhaps be helpful to the student if the pH of familiar laboratory reagents such as decinormal hydrochloric and acetic acids is calculated.

We may do this if we know the normality of the solution, and its degree of dissociation.

As Macleod points out, decinormal hydrochloric acid is dissociated 91 per cent., it is therefore 0.091 N or 9.1×10^{-2}. The P_H is found by subtracting from the power of ten, the logarithm of the reciprocal of the normality in hydrogen ions. Thus:— Log. 9 1 is .96, now -2 minus .96 = -1.04, which is the pH sought.

Again, acetic acid in decinormal solution is dissociated 1.3 per cent; it is therefore 0.0013 N in hydrogen ions, or 1.3×10^{-3}. Now, log. 1.3 is .11; subtracting .11 from -3, we get -2.89, and the pH is therefore 2.89.*

To find the normality in ordinary notation, we must subtract the pH from the next higher whole number, and take the antilogarithm of this number.

Thus, if the P_H be 7.45, subtracting this number from 8, we get 0.55. Now, the antilogarithm of this is 3.55, and the hydrogen ion concentration, or C_H is therefore 3.55×10^{-8}. (21)

We would again lay stress on the fact previously mentioned, i.e., the formula of Nernst shows that for a tenfold difference in the hydrogen ion concentration of the fluid under examination, the electrode potential changes by only 0.058 volt.

In the case of the concentration cell previously mentioned, it is found that " when a univalent electrolyte is employed, an e.m.f. of 0.058 volt is developed where one solution is ten times the concentration of the other, and the electrode potential between monad metal and a normal solution of the corresponding metallion is thus 0.058 volt smaller than the electrode potential between the same metal, and a decinormal solution of the metallion." (4)

* Algebraic sum would probably be the better expression to use in these cases.

Schmidt (22) has discussed the matter of pH in a way which makes the use of this notation as a measure of reaction, more intelligible to the student He says the term pH is given to the exponent of ten taken as a positive number This is the most rational system since all values are expressed in the same units Thus $C_H = 5\ 03 \times 10^{-10}$ can be expressed entirely as a power of ten

$$5\ 03 = 10^{0\ 702} \text{ (since } \log_{10} 5\ 03 = 0\ 702)$$
$$C_H = 10^{0\ 702} \times 10^{-10}$$
$$= 10^{-9\ 298}$$
$$\text{Therefore } P_H = 9\ 298$$

Another example To find P_H when $C_H = 0\ 409 \times 10^{-7}$—

$$P_H = \log_{10} \frac{1}{C_H}$$
$$P_H = \log_{10} 1 \ \log_{10} CH$$
$$\log_{10} C_H = 10^{-7} \times 10^{1\ 612}$$
$$= 8\ 612$$
$$P_H = 17\ 388 - 10$$
$$P_H = 7\ 388$$

Or starting from the log 8 612 one may convert this into the negative form by subtracting from 0 000 and obtain the required result thus —

$$\begin{array}{r} 0\ 000 \\ 8\ 612 \\ \hline -7\ 388 \end{array}$$

Which is the required pH

A useful method of calculating the hydrogen concentration decimal points of the pH from right to left as abscissae while it one draws a diagonal line on semi log paper and plots the first decimal points of the pH from right to left as abscissae while the hydrogen ion concentrations are plotted from 0 1 to 1 0 as ordinates

If for example one wishes to convert pH 6 7 into a corresponding hydrogen ion concentration one finds by examination that 6 7 cuts the diagonal line at 0 2 and the concentration is $0\ 2 \times 10^{-6}$

By plotting the electrical potentials against the hydrogen ion concentration on semi log paper one can if necessary avoid the use of Sörensen s exponent or pH

In conclusion the writer would like to put on record his appreciation of the many kindnesses extended to him over a number of years by Prof. Osborne, but for whose encouragement and help this work could not have been undertaken.

The author has not hesitated to quote freely from the authorities named, and trusts that the student may be led to read at length the articles referred to.

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Thanks are also due to Dr. W J. Young, of the Biochemical Department of the Melbourne University, for his kindness in reading the proofs of the article.

ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR 1920

The Council herewith presents to Members of the Society the Annual Report and Statement of Receipts and Expenditure for the past year

The following meetings were held —

March 11th —Annual Meeting

The following office bearers retired by effluxion of time President J A Kershaw F E S Vice Presidents Professor Ewart and F Wisewould Hon Treasurer W A Hartnell Hon Librarian Dr Griffith Taylor Hon Secretary Professor Ewart Members of Council Professor Skeats Professor Laby and Messrs Chapman Herman Shephard and Sweet

The following were elected President Professor Ewart Vice Presidents F Wisewould and Professor Laby Hon Treasurer W A Hartnell Hon Librarian Dr Griffith Taylor Hon Secretary J A Kershaw Members of Council Professor Skeats Professor Laby and Messrs Chapman Herman Shephard and Sweet

The Annual Report of the Council and Financial Statement were read and adopted

At the close of the annual meeting an ordinary meeting was held Papers read (1) New Australian Tabanidae with notes on previously described species by E W Ferguson M B Ch M (2) Description of a New Species of Mochlonyx from Australia by E W Ferguson M B Ch M Exhibit Dr E F J Love showed a simple model illustrating some phenomena of Resonance and Polarisation Mr Barkley showed photographs of the Christmas Meteor which fell at Penshurst Western District in 1917 specimens of Eucalyptus Luehmani and colour photographs of same example of penetration caused by extreme wind force showing a hardwood picket in which a small piece of galvanised iron had penetrated its entire width meteorological maps, showing—(1) Wet season rainfall (2) evaporation, (3) snow falls (4) wet season maps Mr Chapman showed specimens of Travertine from Yass New South Wales

April 8th:—Papers read: "Heliotropism and Nyctinasty of Flowers," by D. A. Herbert, B.Sc. Exhibits: Professor E. W. Skeats showed specimens of Jarosite (hydrated sulphate of iron and potassium), and Natrojarosite, from near Anglesea, Victoria. Dr. J. M. Baldwin showed a photograph of a Total Eclipse of the Sun, being a print from one of the photographs taken at Sobral on 29th May, 1919. Seven comparison photographs were taken under similar conditions with the same apparatus between 13th and 18th July, and show star images like those on the print exhibited. Mr. J. A. Kershaw showed an Obsidianite, obtained at Glenalbie, Blackwood Forest, Wonthaggi, Victoria, showing a peculiar circular depression on the upper surface, and unusually large and numerous pittings on the lower surface.

Professor W. E. Agar, M.A., D.Sc., and Captain John King Davis were elected members; Mr. W. Langford, B.Sc., B.M.E., a country member, and Mr. B. Macdonald, Mr. F. E. Moore, M.B.E., and Mr. Edwin T. Quayle, B.A., associates.

May 13th:—Papers: (1) "Aboriginal Flaked Stone Knives," by George Horne, M.A., M.D.; (2) "Abnormalities in the Flowers of Eriostemon obovalis, and Glossodia," by Miss J. Cookson, B.Sc.

Exhibits: Dr. Griffith Taylor showed a series of diagrams illustrating Evolution of Culture and Language; Mr. J. A. Kershaw showed a fine example of Fasciation in the Stem of Casuarina.

Mr. A. D. Mackay, M.M.E., B.Sc., and Senator J. D. Millen were elected members, and Mr. H. F. Clinton and Miss Francis Stevenson associates.

June 10th:—Papers: "A Palaeographical Deduction drawn from the Existence of the Crystalline Schist Formation of Central Celebes," by E. C. Abendanon (communicated by Mr. H. Herman, B.C.E. Exhibits: Professor T. H. Laby showed three Electrode Valves used in Wireless Telegraphy, Telephony, and Wire Telephony. Mr. Chapman showed an example of a Fossil Nautilus from Murray Cliffs, South Australia. Mr. Leo Miller and Mr. E. L. Piesse were elected members, and Dr. Sidney Pern an associate.

July 8th:—Papers: (1) "The Relationship of the Sedimentary Rocks of the Gisborne District, Victoria," by W. J. Harris, B.A., and W. Crawford. (2) "A Geologist's Notes on Water Divining," by Griffith Taylor, B.A., B.E., D.Sc. (3) "A Re-

vision of the Australian Cicadidae," Part I., by Howard Ashton. Mr. F. A. Cudmore was elected a member.

August 12th:—Papers: (1) "Organisation of Science in Australia," by Professor T. H. Laby, M.A. (2) "Note on the 'Dimpling' of Granite Hills in Sub-Arid Western Australia," by J. T. Jutson. (3) "An Example of Gravitational Drift of Rock Debris in Parallel Lines in Sub-Arid Western Australia," by J. T. Jutson.

Dr. W. Heber Green and Mr. J. Goodwin were elected members.

September 9th.—Papers: (1) "Possibilities of Modifying Climate by Human Agency, with special application to South-eastern Australia," by E. T. Quayle, B.A. (2) "Revision of the Genus Pultenaea," Part II., by H. B. Williamson. Exhibits: Mr. Chapman exhibited some exceptionally well preserved Triassic Leaves in Pipeclay from Petrie's Quarry, Brisbane, Queensland, and Mr. H. Barkley showed some interesting examples of Fractures in Glass. Mr. Robert Lowther was elected a member, and Mr. W Crawford a country member.

October 14th:—Paper: "A Generalisation of Elementary Geometry," by D. K Picken, M.A. Dr. J. M. Baldwin delivered a lecture on "Giant Stars and Dwarf Stars."

November 11th:—Paper: "A Description of the Bracebridge Wilson Collection of Victorian Chitons, with descriptions of Two New Species," by Edwin Ashby, F.L.S (communicated by J. A. Kershaw). Mr. A E. V. Richardson, M.A., B.Sc., delivered a lecture on "The Application of Genetics to Plant Breeding" The lecture was illustrated by diagrams and specimens.

December 9th:—Papers: (1) "Researches into the Serological Diagnosis of Contagious Pleuro-Pneumonia of Cattle," by G. G. Heslop, M.V.Sc., D.V.H. (Walter and Eliza Hall Fellow). (Communicated by Professor H A. Woodruff) (2) "New or Little-known Victorian Fossils in the National Museum Part XXV.: Some Silurian Corals," by F Chapman, A L.S (3) "Contributions to the Flora of Australia" No 29. By A. J. Ewart, D.Sc., Ph. D. (4) "The Estimation of Acidity," by Dr. J. M. Lewis. (Communicated by Professor W A. Osborne.

Professor W. A. Osborne delivered a lecture on "Physiological Factors in the Development of an Australian Race." Exhibit: Dr. P. Th. Justesen, by invitation, showed specimens of Rafflesia preparations in alcohol, and a series of lantern slides of

same. Mr. W. S. Littlejohn was elected a member, and Miss Margaret Nicholson an associate.

During the year ten members, two country members, and six associates were elected, including one associate elected as a member; one associate resigned, and two members and one associate died.

The attendances at the ordinary meetings during the year have been larger than for some years past, and the interest in the work of the Society has been well maintained.

The attendances at the Council meetings were as follow:—Mr Kershaw, 10; Professor Ewart, 9; Mr Hartnell, 9; Mr. Wisewould, 8, Mr. Chapman, 8; Professor Osborne, 7; Dr Summers, 7; Mr. Shephard, 7; Professor Laby, 6; *Dr. Griffith Taylor, 6; *Dr Baldwin, 5; Mr Picken, 5; Mr Dunn, 4; *Professor Skeats, 3; Mr Herman, 3; Mr Richardson, 2; *Dr. Green, 2; *Professor Agar, 2.

Vacancies on the Council were caused by the death of Mr. George Sweet, and the resignations of Professor Sir Baldwin Spencer and Dr Griffith Taylor, and were filled by the election of Dr. Heber Green, Dr. J M Baldwin and Professor W E Agar.

Dr Griffith Taylor, whose resignation as Hon Librarian followed his appointment as Associate Professor of Geography in the Sydney University, carried out useful work in the re-arrangement of the library, in which he was ably assisted by the Assistant-Librarian, Mr L Scott.

During the year, about 1911 volumes and parts were added to the library. Two additional book cases were purchased, and placed in the Council room These have greatly relieved the overcrowded state of the shelves, and allowed for a more convenient arrangement of the periodicals

Abstracts of the papers read at each meeting have been published in "Science and Industry," and similar abstracts are being sent to "Nature."

Part II of Volume XXXII of the "Proceedings" was issued in September. The printing of this part was unfortunately delayed for some months owing to a printers' strike, followed by other industrial troubles. The issue of Part I. of Volume XXXIII. was consequently found impossible, and the Council therefore decided that Parts I. and II. should be issued together.

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* Absent on leave, resigned, or elected during the year.

It is expected that this volume will appear about the end of April

The heavy increase in the cost of printing the Society's publications has now become a matter of serious concern and in all probability will necessitate a reduction both in printing matter and illustrations thus seriously affecting the usefulness of the Society's work

Owing to lack of funds no binding has been possible during the year while repairs to the building and fences which cannot much longer be delayed have had to be held over

It is with much regret we have to record the loss by death of Mr George Sweet and Mr John Booth both members of long standing

The late Mr George Sweet F G S was born on September 16th 1844 at Salisbury England where he was brought up as a contractor In 1866 he came to Australia settling in Brisbane Queensland and in the following year arrived in Victoria where he later established his business of brick tile and pottery works at Brunswick

He was a member of the Society from 1887 was elected a member of the Council in 1901 and President in 1905 He took an active interest in the work of the Society and his practical experience and advice were ever at the disposal of the Council He was a keen geologist and made extensive collections of fossils from the carboniferous and cretaceous strata of Queensland and also in New South Wales Tasmania and various parts of Victoria Much of his material which was of considerable scientific value is now in the National Museum Melbourne In 1888 at the request of the late Sir Frederick McCoy then Director of the National Museum he spent considerable time in investigating the rocks of the Mansfield district generously placing his time and experience at the disposal of the Museum and obtained an extremely interesting and valuable collection of carboniferous fish and plant remains since described in the Memoirs of the National Museum Among the new species obtained were the remarkable selachian *Gyracanthides murrayi* for which McCoy established a new genus and *Elonichthys sweeti* He also investigated the Permo Carboniferous glacial beds near Bacchus Marsh where he found the interesting fossil fern described as *Taeniopteris Sweeti* and was second in command of the second Funafuti Expedition under Professor (now Sir) Edgeworth David in 1897 He was for many years a member of the Field

Naturalists' Club of Victoria, and of the Australasian Association for the Advancement of Science since its inauguration. He died on 14th March, 1920. Mr. Sweet's only surviving daughter, Dr. Georgina Sweet, is Associate Professor of Zoology in the Melbourne University.

The late Mr. John Booth, B.Sc., M.C.E., was one of the two oldest surviving members of the Society. He was born in 1857, at "Tragowell," Kerang, Victoria, where, in the early days, he met the Burke and Wills Expedition during their halt of three days at this station. He removed later with his parents to Coburg. Up to the age of eighteen years he attended Wesley College, passing on to the Melbourne University, where he took his B.C.E. degree in 1878, and gained that of M.C.E in 1884, the first, it is understood, to take this degree in Australia. Afterwards he practised his profession, being engaged in railway construction and in the Melbourne and Metropolitan Board of Works. Later in life he returned to the University, and in 1907 obtained the degree of B Sc, specialising in biology. While interested in various branches of science, he devoted himself for some time to the study of Australian Batrachians. He was a member of the Microscopical Society of Victoria, in the work of which he took a keen interest, and held the office of President, and was for many years a member of the Field Naturalists' Club of Victoria. His kind and sympathetic nature and unfailing courtesy made him many friends, who mourn his loss He died suddenly on 25th July

During the year it was decided to arrange for a series of short popular lectures on subjects of general interest, to follow the reading and discussion of papers The first of these was delivered at the October meeting by Dr. J. M. Baldwin, followed at the November and December meetings by Mr. A. E. V. Richardson, M.A., B Sc. and Professor W. A. Osborne respectively. The lectures were well attended, and much appreciated, and it has been decided to continue these as far as possible throughout the year.

The Hobart meeting of the Australasian Association for the Advancement of Science was held in Melbourne on 10th January last. All arrangements had been completed for the meeting to be held in Hobart, but, owing to the means of transport being interfered with by a seamen's strike, these had to be cancelled at the last moment, and arrangements made, at very short notice, for the meeting to be held in Melbourne. The Congress, however,

proved a most successful one, and, considering the unusual circumstances, was well attended. A long and interesting series of papers on various subjects of scientific interest were dealt with, and a number of excursions to places of interest was carried out. Three delegates from this Society attended The next meeting of the Association will be held in Wellington, New Zealand, in January, 1923.

Financial Statement for the year ending 28th February 1921

RECEIPTS			EXPENDITURE		
To Balance at 29 2/20		£92 14 7	Publication—		
Subscriptions—			Printing	£247 17 3	
Members	£156 9 6		Distribution	20 0 0	
Associates	60 17 6				£267 17 3
		217 7 0	Maintenance—		
Rents—			Assist Secretary	£30 0 0	
Comwlth Government	£50 0 0		Caretaker's A/cs	19 16 0	
Field Naturalists Club	12 0 0		Rates	8 7 8	
		62 0 0	Repairs	2 8 9	
Sales of Publications		53 6 2	Insurance	5 1 3	
Victn Govt Grant in Aid		100 0 0	Petty Cash—Hon Treas	4 0 0	
			Hon Sec	2 0 0	
			Sundries—Gas Elec Light Tools etc	7 8 4	
					79 2 0
			Cash Charges—		
			Commission	21 3 6	
			Bank Charges	0 5 0	
					21 8 6
			Library		61 7 0
			Balance at 28th Feb 1921		95 13 0
		£525 7 9			£525 7 9

(Signed) WM A HARTNELL, *Hon Treas*

We have examined Pass Books and hereby certify that all amounts entered herein have been paid to the credit of the Society We have seen receipts for all payments

(Signed) JAMES E GILBERT, } *Hon*
A E V RICHARDSON, } *Auditors*

N B —There is a liability estimated at £250 for the printing of the Proceedings now in the press and expected to be published at the end of April

Royal Society of Victoria.

1920

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Baldwin, J. M., D.Sc., Observatory, Melb. 1915
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Barrett, Sir J. W., K.B.E., C.M.G., M.D., M.S., Collins-street, Melb. 1910
Berry, Prof. R. J. A., M.D., C.M., F.R.C.S. Edin., F.R.S.E., University, Melb. 1906
Boys, R. D., B.A., Public Library, Melb. . 1903
Brittlebank, C. C., "Queensgate," St. George's-road, Elsternwick. 1898

Chapman, F., A.L.S., National Museum, Melb. ... 1902
Cudmore, F. A., 17 Murphy street, South Yarra . 1920

Deane, H., M.A., M. Inst. C.E., 14 Mercer-road, Malvern 1914
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Dunn, E. J., F.G.S., "Roseneath," Pakington-street, Kew, 1893
Dyason, E. C., B.Sc., B.M.E., 60 Queen-street, Melb. 1913

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Green, W. Heber, D.Sc., University, Melbourne . 1920
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Goodwin, J., Lands Department, Melbourne . . 1920
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Hartnell, W. A., Universal Chambers, 325 Collins-street, Melb. 1900
Herman, H., B.C.E., M.M.E., F.G.S., Department of Mines, Melb. 1897
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Mitchell, J. H., M.A., F.R.S., University, Melb., 52 Prospect Hill Road, Camberwell. 1900

Monash, Lieutenant-General Sir John, G.C.B., M.C.E., B.A., LL.B., 360 Collins-street, Melb. 1913

Miller, L., Melbourne Mansions, Collins-street, Melb. 1920

Millen, Senator J. D., Batman House, 103 William-street, City. 1920

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Picken, D. K., M.A., Ormond College, Parkville 1916
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Pratt, Ambrose, M.A., 376 Flinders-lane, Melb. 1918

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Schlapp, H. H., 31 Queen-street, Melb. 1906
Shephard, John, "Norwood," South-road, Brighton Beach. 1894
Skeats, Prof. E. W., D.Sc., A.R.C.S., F.G S., University, Melb. 1905
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Summers, H. S., D.Sc., University, Melb. 1902
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Syme, G. A., M.B., M.S., F.R.C.S., 19 Collins-street, Melb. 1913
Syme, Geoffrey, "Banool," Studley Park-road, Kew, Vic. 1913

Taylor, R., 31 Queen-street, Melb. 1907
Taylor, Griffith, Assoc. Prof, B.A., B.E, D.Sc., University, Sydney, N.S.W. 1918
Thom, L. N., B.Sc., Patent Office, Melbourne . .. 1910

Walcott, R. H., Technological Museum, Melb. . . . 189'
Wisewould, F., 406 Collins-street, Melb. 1902
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COUNTRY MEMBERS.

Adcock, G. H., F.L.S., Viticultural College, Rutherglen, Vic. 1914
Allen, G. M., F.R.M.S., Stribling's Buildings, Euroa, Vic. 1918
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Collyer, W J B Sc, 115 Raglan street, Ballarat 1919
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Drevermann, J, Longerenong Agricultural College, Dooen, Vic 1914

Easton, J G Geological Survey, Corryong, Vic 1913

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Harris, W J B A, High School, Kyneton Vic 1914
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James, A B A, B Sc High School, Bendigo 1917

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Langford, W G, M Sc, B M E, Vailala Oilfields, Papua 1918
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Roberts, J K, Cavendish Laboratory Cambridge, England 1919

Whitelaw H S, Geological Survey Office, Bendigo, Vic 1914

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Dendy, Professor Arthur, D Sc, F R S, Sec L S, King's College, London, 1888

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Merrel, F P, Rhodesian Museum, Buluwayo 1919

Associates.

Allen, Miss N. C. B., B Sc., Physics Dept., University, Melb. 1918

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Ashton, H., "The Sun," Castlereagh-street, Sydney, N S W. 1911

Bage, Mrs. Edward, "Cranford," Fulton-street, St. Kilda, Vic. 1906

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Baker, F. H., 167 Hoddle-street, Richmond 1911

Barkley, H., Central Weather Bureau, Melb. . . . 1910

Bordeaux, E. F J., G.M.V C., B ésL , 427 Mount Alexander-road, Moonee Ponds. 1913

Brake, J., B Sc., Mont Albert . 1913

Breidahl, H., M.Sc., M.B., B S., 36 Rouse-street, Port Melb. 1911

Brodribb, N. K. S., Cordite Factory, Maribyrnong 1911

Bryce, Miss L. M , B.Sc., Biology School, University, Melb 1918

Carton, M , M.A., University, Melb. 1913

Chapple, Rev. E. H., The Manse, Warrigal-road Oakleigh. 1919

Clendinnen, F. W. J., "Haven," Hawksburn . 1918

Clinton, H F., Produce Offices, 605 Flinders-street, City. 1920

Cook, G., M Sc., B.M., Elphin-grove, Hawthorn . . 1919

Cookson, Miss I. C., B.Sc., 154 Power-street, Hawthorn, Vic. 1916

Coulson, A. L , Geol School, University, Melbourne 1919

Crespin, Miss R., Geol. School, University, Melbourne 1919

Danks, A. T., 391 Bourke-street West, Melb. 1883

Fenner, C. A., D.Sc., Education Department, Flinders-street, Adelaide, S.A. 1913

Fenton, J. J., 14 Densham Road, Armadale 1910

Ferguson, W. H., 37 Brinsley-road, E. Camberwell ... 1894

Finney, W. H., 40 Merton-street, Albert Park, Vic. 1881

Gabriel, C. J., 293 Victoria-street, Abbotsford, Vic. 1908

Gatliff, J. H., 5 Fawkner-street, S. Yarra 1898

Gordon, Miss M., Botany School, University, Melbourne. 1919

Hardy, A. D., F.L.S., Forest Department, Melb. 1903

Hart, T. S., M.A., B.C.E., F.G.S., Scoresby .. 1894

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Hoadley, C. A., M.Sc., B.M.E., Technical School, Footscray. 1910

Holmes, W. M., M.A., B Sc., University, Melb. . 1913

Howitt, A. M., Department of Mines, Melb. 1910

Hunter, Stanley B., Department of Mines, Melb. ... 1908

Jack, A K., M.Sc, "Kilkerran," Williams-street, Brighton, Vic. 1913

Jobbins, G. G., Electric Lighting and Traction Co., Geelong, Vic. 1902

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Junner, N., M.Sc, M C., Geology School, University, Carlton. 1912

Jutson, J. T., B Sc. 26 Jolimont Terrace, E Melb 1902

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Keble, R A., Department of Mines, Melb. ... 1911

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Luher, R. E., B.A., "Age" Office, Melbourne 1919

Luly, W. H., Department of Lands, Public Offices, Melb. 1896

McInerney, Miss K., B.Sc, Geology School, University, Melb. 1918

Macdonald, B, Meteorological Bureau, Victoria-street, Melbourne 1920

Maclean, C. W., "Devon," Merton-avenue, Elsternwick. 1879

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Mackenzie, G., 1 High street, Prahran, Vic. . 1907

McLennan, Miss Ethel, B.Sc., University, Melb. . 1915

Melhuish, T. D. A., Geol. School, University, Melbourne 1919

Mickle, K. A., D.S.O., Burma Mines Ltd., Namtie, via Manpive, Northern Shan State, Burma. 1911

Mollison, Miss E., M.Sc., Royal Crescent, Camberwell. 1915

Montgomery, J. N., Upoia Oilfields, Papua 1912

Morris, M, M.Sc., Geology School, University, Melb. 1912

Moore F E, M B E, 4 Mont Albert road west East Kew	1920
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Trudinger W, Gerald street, Murrumbeena	1918
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Webster R M D The Eyrie Eaglemont Heidelberg	1918
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[Issued 9th May 1921]

PROCEEDINGS

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VOL. XXXIV. (NEW SERIES).

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(Containing Papers read before the Society during 1921)

THE AUTHORS OF THE SEVERAL PAPERS ARE INDIVIDUALLY RESPONSIBLE FOR THE SOUNDNESS OF THE OPINIONS GIVEN AND FOR THE ACCURACY OF THE STATEMENTS MADE THEREIN

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CONTENTS OF VOLUME XXXIV.

[Proc. Roy. Soc. Victoria, 34 (N.S.), Pt. I., 1921].

Art. I.—*Blood and Shade Divisions of Australian Tribes.**

By Sir BALDWIN SPENCER, K.C.M.G., F.R.S.

[Read 10th March, 1921].

Very much confusion and uncertainty exist in regard to what have been described as the blood and shade divisions of Australian tribes.

The first really definite allusion to anything of the kind is probably that of Bunce in 1895.[1] He says: "The merest observer, who has had the least experience travelling through the bush, must have remarked that there exists a vast difference of complexion in the different individuals comprising the various tribes. It is this difference in complexion which constitutes the *castes* spoken of by Dr. Leichardt. The tribe of aborigines, to which my attention was first directed, in whom I observed this very singular feature in crossing the blood, were a tribe inhabiting a portion of the country on the Condamine River, called Terreboo, now fully occupied by the squatters, among whom are John Dangar and Richard Birrell, Esquires. It was the latter gentlemen who furnished me with many interesting particulars relating to the Terreboo tribes.

"The two castes were distinguished by the words Cobbi, masculine; and Cobbitha, feminine; Hippi, masculine; and Hippitha, feminine.[2] The first, or Cobbi and Cobbitha, are those having the blackest complexion, and the latter are those many shades lighter. In their unions, marriages between sexes of the same castes are strictly prohibited, or in other words, a Cobbi must join his fate with that of a Hippitha, and *vice versa*."

The late Mr. R. H. Mathews[3] stated that a form of kinship organisation existed which he described as "Bloods and Shades,"

* Read at the Hobart meeting of the Aust. Assoc. Adv. Sc., held in Melbourne, Jan., 1921.

1. Bunce, "Language of the Aborigines of the Colony of Victoria, etc," 1859, p. 59.

2. Cobbi and Cobbitha are evidently the equivalents of the now well-known Kubbi and Kubbitha, Hippai and Hippitha those of Ipai and Ipatha. The existence of two other "castes" seems to have escaped the notice of Mr. Bunce and his informant, as also that of the two moieties, Kupathin and Dilbi. We may conclude that their knowledge of the natives was very imperfect and unreliable.

3. Mathews, R. H. Proc. R.S., N.S.W., 1905, p. 216.

though he seems rather to have confused the words "shade" of blood, and "shadow" or "shade" cast by a tree. Mr. R. H. Mathew's account is very vague, and somewhat difficult to understand, as it seems to refer to some form of organisation running, as it were, across the ordinary, normal organisation. It must also be remembered that he was dealing with very decadent tribes, who had, for nearly half a century, been in contact with white men, and whose numbers also were so depleted that, of necessity, old marriage customs had become profoundly modified, whilst more important still the beliefs of their forefathers were to them, for the most part, only a matter of past history in which they took practically no interest.

Recently Mrs. Langloh Parker[4] stated that the moiety names of the Euahlayi tribe in New South Wales indicated "light blooded" and "dark blooded" respectively. Mrs. Bates[5] in regard to S.W. Australia states that two of the sub-class, but not class or moiety, have in addition to their ordinary ones of Tondaroop and Ballarook, names indicating fair- or dark-skinned people, though it must be remembered that the earlier investigators gave these names, respectively, as fish-hawk and opossum. Mrs. Bates also says that "the two class system, similar to that of the Dieri, but with different names, obtains in the south-west of Western Australia, and also bears on colours—white cockatoo and crow, light and dark purple. . . . Somewhere south-east of Coolgardie the four class system dies out and, as the natives of the south-east say, 'marriages and relations go by faces (probably light and dark colour).'"

The Rev. J. Mathew[6] states that the well-known moiety names in the Kamilroi tribe, Dilbi and Kupathin, indicate light and dark blood and complexions, and that Kilpara and Mukwara, two equally well-known moiety names, mean, not eagle-hawk and crow, as he had previously told us when writing in support of his bird-conflict theory, but really straight and curly hair. He also states that in the Kabi and Wakka tribes, "the four gradations of colour correspond to the four classes."

One cannot help wondering whether these kaleidoscopic changes and variations in the meaning of names of which, at

4. Parker, Mrs Langloh "The Euahlayi Tribe," 1905, p. 215.
5. Bates, Mrs Daisy "Social Organisation of Some West Australian Tribes," Report A.A.A.S., Melbourne, 1913
6. Mathew, Rev. J. "Two Queensland Tribes," 1905, pp. 32, 36, 142. Journal Anth. Inst Great Britain, Vol. xl, 1910, pp. 35 and 166. "Eaglehawk and Crow," 1899

all events in certain cases, the natives themselves have only a dim, very unreliable and inconsistent knowledge, but are fitted in to suit a theory either of the conflict of curly and straight haired men, dark and light coloured, or sluggish and rapid blooded peoples, are not due to the desire of the natives to explain the long lost significance of the moiety names.

On philological grounds Mr. Mathew has attempted to show the equivalence of various moiety names to one another, and has attributed to them meanings, such as eagle-hawk and crow, which, in certain cases, are either apparently quite unknown to the natives who use them, or concerning the exact application of which the natives themselves are uncertain.

Philological evidence derived from tribes that have no written language, amongst whom words are continually changing, and amongst whom, further, the same word in different tribes may have quite a different meaning, more especially when, in order to homologise words in use in various tribes, such as the names of moieties, the elision or insertion of consonants, and a change of vowels is necessary, must be received with the greatest caution.

Whilst fully realising that the question of "Bloods and Shades" requires further investigation, more especially in view of the fact that Dr. Rivers has drawn attention to a somewhat similar feature in regard to the dual organisation in certain parts of Melanesia, there are certain serious difficulties that arise on closer examination of the matter so far as the evidence as yet brought forward is concerned. I venture to suggest that the reporters of such evidence as we possess, so far at least as it relates to Australia, have scarcely recognised sufficiently what it implies in regard to the colour sense and knowledge, both anatomical and physiological, possessed by the aboriginals. In the first place, when we are told that the Australian aboriginal actually distinguishes the shades of colour of skin and blood, or the straightness or curliness of hair, we may feel quite certain that we have not arrived at the true significance of the matter. I have tested natives in many Australian tribes in regard to their colour sense by means of the recognised colour tests. So far as my experience goes they only differentiate between, and have distinct names for, what we call black, white, red and yellow. I am, of course, only speaking of the aboriginal in his natural state. This is to be associated with the fact that charcoal, gypsum or pipeclay, red and yellow ochre are practically

the only colour materials available to him for use during the performance of his ceremonies, and therefore his appreciation of colour has been limited to these few pigments. Just as in the development of colour amongst flowers, blue is the highest and latest, so amongst human beings blue seems to have been the latest pigment discovered and appreciated, and it was not, so far as I am aware, before the white man, most unfortunately, introduced Reckitt's Blue into Australia, Melanesia and Polynesia, thereby spoiling aboriginal art, that the savage had any distinct appreciation of this colour. In the Kakadu tribe, for example, the same word is used for blue and green, and the natives do not discriminate between the two, nor do they between black, brown and grey. It is not a case of having one word to describe two or three colours which in reality they differentiate, but they do not, apparently, distinguish the one from the other.[7] One day amongst the Kakadu tribe, on the Alligator River in the far northern part of the Territory, I was sitting under a grove of banana trees, and three natives, with whom I was discussing the question of colour, told me that the green leaves all around and above them were the same colour as the sky. It may be said in passing that the presence of a blue pigment on any Australian ornament or implement that finds its way into one or other of our museums is regarded by all Curators as clear proof that the tribe from which it comes has lost its primitive outlook on art.

It appears to me that the theories of Mr. Mathew and others postulate a fine colour sense that at least our Australian aboriginal does not possess. Not only is this so, but, after most careful examination, made again with the aid of standard colour tints, comparing these with the actual colour of the skin of very many natives in various tribes, I have not been able to discriminate in any way between the colours of the members of the different moieties or classes of any tribe. In the southern Arunta the colour of the women was slightly, but only

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7. It is somewhat difficult to express this matter accurately If shown black, brown and grey objects, such as skeins of wool, or coloured cardboard, they will apply the same term to each. On the other hand, if (a) shown an object of a particular shade of colour such as their own skin, and (b) asked to match this with one of three or four shades of chocolate brown, they will, after consideration, usually pitch on the correct one.' Black, brown and grey are apparently, to them, only what we should call "shades" of the same colour, indistinguishable from one another unless placed side by side

very slightly, lighter than that of the men, but this had no reference whatever to the moieties, and in all other tribes there was no difference. One has to be very careful in regard to questions of colour because, for example, women in mourning plaster themselves all over with pipe clay, whilst men are continually decorating themselves with charcoal, pipe clay or red and yellow ochre. So far as children are concerned I could find no difference whatever. Every child at birth is copper-coloured, but in the course of a few days the skin darkens and assumes the chocolate brown of the adult.

The only way in which to judge accurately of the true colour of the skin is to cut a small square in a piece of white paper and then compare this isolated patch with a series of standard tints, such as are given in Broca's "Instructions Anthropologiques Générales." Casual observations of writers who say that they have noticed variations in the colour of various aboriginals are absolutely of no value and moreover are very misleading. Bunce's statement, quoted above, that "there exists a vast difference of complexion in the different individuals comprising the various tribes" is a typical example, and also a most extraordinary one It is a very careless, rash conclusion, formed by a man with no idea of the need of scientific precision, but one who would usually be described as a "highly intelligent observer"—a most dangerous individual, at least so far as anthropology is concerned.

The "Blood and Shade" theory assumes that one moiety is, or was, originally dark, the other lighter, and that, whatever these physical differences may be between the two moieties, they are restricted, respectively, to the members of each of the latter. This raises an insuperable difficulty from a biological point of view, when it is remembered that in some tribes' descent is counted in the female, and in others in the male line. In a female descent tribe the children of a "dark-blooded" father, according to this theory, will all be "light-blooded"; in a male descent tribe they will all be "dark-blooded." That is, the father or mother, as the case may be, hands on, without exception, and exclusively, his or her dark or light blood, curly or straight hair, or, in the Melanesian peoples, as described by Dr. Rivers, his or her mental characters to all of his or her children. To put it otherwise, in the case of a dark-blooded brother and sister: in a male descent tribe all the children of the former will be "dark-blooded," and all those of the latter will be "light-blooded";

in a female descent tribe all the children of the brother will be "light-blooded," and all those of his sister "dark-blooded."

It is difficult to form any theory as to what the aboriginal really means by this differentiation of "shade" and "blood," so far as actual colour is concerned, and yet the idea is so widely spread that there must be something behind it, though this, I feel sure, has nothing to do with actual "colour" or "shade," in regard to which there is no difference so far as the members of different moieties are concerned. In connection with this I was much struck with the fact, when minutely examining one day twenty men of the Arunta tribe, representing both moieties and all sub-classes, that not only was I myself unable to detect any difference in colour amongst them, but the natives themselves were equally unable to do so.

After a very careful, long and close examination of natives belonging to many tribes from Lake Eyre in the south across the continent to Darwin in the north, and in the Territory from Daly River on the west to the Gulf of Carpentaria on the east, my experience has been that, though there are great variations in physical measurements, yet, on the other hand, so far as colour is concerned, there is an extraordinary uniformity, and no indication whatever, physically or mentally, of the union of two distinct races, such as is assumed to have taken place by various writers The extraordinary variations in regard to physical structure, customs, beliefs and arts of Australian aboriginals cannot possibly be accounted for, or explained by such a theory.

[PROC. ROY. SOC. VICTORIA, 34 (N.S.), PT. I., 1921].

ART. II.—*The Age of the Ironstone Beds of the Mornington Peninsula, as adduced from the Marine Fauna.**

BY FREDERICK CHAPMAN, A.L.S., F.R.M.S.
(Palaeontologist to the National Museum, and Lecturer on Palaeontology, Melbourne University.)

[Read 14th April, 1921.]

The Related Tertiary Beds.

This peninsula is bounded on the west by Port Phillip Bay and on the east by Western Port Owing to the dissection of this area by faulting, and also through the complication of its earlier structural features by local flows of basalt of the Older Period, which partially obscures an undeveloped river system of Miocene times, the geological succession of the various Tertiary beds are here difficult to make out in true detail.

As regards the position of the Grice's Creek and Balcombe Bay fossiliferous marine marls, these fall into line with beds in other areas, as at Muddy Creek (lower series) and the lower beds in the Altona Bay coal-shaft and the Sorrento Bore, all of which are of Oligocene (Balcombian) age, and therefore are at the base of the Tertiary system as developed in south-eastern Australia.

But between these Balcombian and the Kalimnan beds of the peninsula there should occur a series representative of the great diastrophic movements on sea and land during the Miocene period. The question arises: Have these beds been recognised? In reply to this it may be remarked that geologists have for many years been feeling their way to some kind of conclusion which has a more or less direct reference to the subject matter of this note, without reaching a definite conclusion—hence this present attempt.

Earlier References to the Intermediate Series.

A. E. Kitson (1900), in his "Report on the Coastline and Adjacent Country between Frankston, Mornington and Dromana,"[1] shows, in his accompanying map, the widely spread

* Read at the Hobart Meeting of the Aust. Assoc. Adv. Sc., held in Melbourne, Jan., 1921.

1. Monthly Progress Rep. Geol. Surv. Vict., N.S. No. 12, 1900, p. 12.

nature of the deposit of ferruginous grits, sands and clays, to which the fossiliferous ironstone undoubtedly belongs. He remarks upon them as follows:—

"Eocene(?).—Forming the surface along the coast-line from Frankston to a little below the mouth of Chechingurk Creek, and extending far into the country at the back are thick deposits of fine and coarse ferruginous and non-ferruginous sands, quartz grits and clays On the coast they show in high and low cliffs and sloping banks, extend well up the flanks of the granite and Silurian[2] areas of Mounts Eliza and Martha, and stretch far out across the less elevated portions of the district."

. . . .

"*Until the fossils from the new beds herein mentioned*, or other beds that may yet be discovered, are thoroughly examined and worked out, it is impossible to say definitely if all these strata are Eocene; but, lithologically and stratigraphically considered, the ferruginous and other beds overlying the fossiliferous Eocene clays may reasonably be referred to a much earlier period than the Pliocene, the age to which they have hitherto been assigned by the Survey."

"In some places there appears to be a distinct unconformity between these ferruginous beds and the fossiliferous clays, and in others no such break is noticeable with certainty. . . . They probably belong to the same series that extends along the coast northwards through Beaumaris and Brighton to Melbourne, and which, on the evidence of the Beaumaris beds, are regarded by Messrs Tate and Dennant as of Oligocene age, and by Messrs. Hall and Pritchard as of Miocene age." . .

"The determination of the casts of fossils, which no doubt exist in many other places besides those noticed, will probably prove of more material assistance eventually in this respect than any attempt made on stratigraphical evidence."

In the light of later discoveries of fossils, mentioned in the sequel, not only from Landslip Point, but also from Watson's Creek, near Baxter, and which was to some extent predicted and their value as horizon determinants emphasised as above, by Mr. Kitson, the "(?)Eocene" is now relegated to the Miocene or Janjukian.

The deposition of these beds against sloping banks and sometimes at angles up to 10° seems to point to shore or marine littoral conditions. That these ferruginous beds are older than

2. =Lower Ordovician.

the Beaumaris and Brighton series is proved by the faunal aspect of the fossil casts; and so they underlie the Kalimnan to the north.

Kitson's observations as to the ferruginous beds invariably overlying the fossiliferous clays (Balcombian) are valuable, as that alone fixes their approximate position in the Tertiary series. And lastly, the prediction that fossil evidence rather than the stratigraphical may settle the vexed question as to age and succession can be regarded as prophetic.

T. S. Hall and G. B. Pritchard (1901) in their paper on "Some Sections Illustrating Geological Structure of the Country about Mornington"[3] refer to the ferruginous grits as follows:—

"Ferruginous sands and clays mantle over a great part of the area, and their age is shown to be Eocene[4] by the fossils obtained at Landslip Point. It is, of course, quite within the bounds of possibility that further investigation may show that some of the beds are younger than this; but, in the meantime, we seem justified in referring the ferruginous grits of the district all to the one age"

An interesting point is here revealed, insomuch as the above authors, believing that some of the ferruginous beds may be younger than the "Eocene," thus gave additional proof, now that they prove to be Janjukian, from field evidence, that the Janjukian overlies the Balcombian, since the ferruginous grits and accompanying fossils are superposed on the Balcombian marls.

Messrs. Hall and Pritchard also furnished a list of fossils from Landslip Point, Frankston, which is as follows[5] —

Placunanomia sella, Tate; *Pecten dichotomalis*, Tate; *Amussium zitteli*, Hutton sp.; *Lima bassi*, T. Woods; *L. linguliformis*, Tate; *Spondylus pseudoradula*, McCoy; *Septifer fenestratus*, Tate; *Nucula obliqua*, Lamarck, *Leda vagans*, Tate; *Glycimeris maccoyi*, Johnston sp.; *Arca (Barbatia) celleporacea*, Tate sp.; *Cucullaea corioensis*, McCoy; *Cardita delicatula*, Tate; *Chama lamellifera*, T. Woods; *Cardium hemimeris*, Tate; *Venus (Chione) cainozoicus*, T. Woods sp.; *Corbula pyxidata*,

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3 Proc Roy. Soc Vict., Vol xiv. (N S), pt i., 1901, p. 44.

4 The Landslip Point Fossils were later shown to be of Janjukian or Miocene age. See Chapman, Mem. Nat Mus, Melbourne, No. 5, 1914, pp. 29, 30.

5 Proc R. Soc. Vict, Vol xiv (N S), pt 1, 1901, pp. 46-53. The nomenclature is here corrected to date

Tate; *Argobuccinum pratti,* Tate sp.; *Lotorium tortirostre,* Tate sp.; *Nassa tatei,* T. Woods; *Lyria harpularia,* Tate; *Marginella propinqua,* Tate; *M. wentworthi,* T. Woods; *Turris* (?)*trilirata,* Harris sp.; *Bathytoma rhomboidalis,* T. Woods sp.; *Bela* (*Daphnobela*) *gracillima,* T. Woods sp.; *Conus cuspidatus,* Tate; *Cypraea subpyrulata,* Tate; *Trivia avellanoides,* McCoy; *Natica hamiltonensis,* T. Woods; *Solarium acutum,* T. Woods; *Turritella murrayana,* Tate; *Siliquaria occlusa,* T. Woods sp.; *Scaphander tenuis,* Harris; *Vaginella eligmostoma,* Tate; *Dentalium aratum,* Tate.

The above list does not seem to include any species which are distinctive of either Balcombian or Janjukian, for they all have an extensive geological range.[6]

A further suite of fossils was recorded from the ironstone band at Landslip Point by the present writer in 1914,[7] the result of an extended search made by Mr. R. A. Keble and himself. These fossils are:—

Placotrochus sp.; *Sphenotrochus emarciatus,* Duncan; *Ditrupa cornea,* L. sp., var. *wormbetiensis,* McCoy; *Terebratula* (?)*aldingae,* Tate; *Magellania garibaldiana,* Davidson sp.; *Pecten foulcheri,* T. Woods; *P.* cf. *flindersi,* Tate; *P. praecursor,* Chapman; *Limatula* sp.; *Cuspidaria subrostrata,* Tate; *Dentalium mantelli,* Zittel; *Latirus* (?)*actinostephes,* Tate sp.; *Oliva* sp.; *Columbarium acanthostephes,* Tate sp.

Among the above fossils, *Ditrupa cornea,* var. *wormbetiensis* is especially typical of Janjukian beds. *Terebratula aldingae* is a restricted Janjukian form, as are also *Pecten praecursor* and *P. flindersi.*

The writer has also (loc. supra cit.) compared these ferruginous gravels with the "older gold drifts" in Western Victoria, where, at Stawell,[8] they contain a fairly extensive series of Janjukian marine fossils.

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6. See F. Chapman, Mem. Nat. Mus. Melbourne, No. 5, 1914, p. 29, par. 3.
7. Loc. supra cit., pp. 29, 30.
8. Vict. Naturalist, Vol. xxi., 1905, pp. 178-189.

Further Evidence of the Miocene Age of the Ferruginous Deposits.

A few months ago my friend, Mr. J. H. Young, of Meredith, who is already known as an enthusiastic and successful collector of fossils, paid a visit to Watson's Creek, near the intersection of the Peacedale and Somerville Roads, half a mile west of Baxter railway station. He there found an ironstone band crossing the creek, which contained fossil casts. Several clearly identifiable specimens of *Pecten praecursor* were found there, a species which is typical of the Janjukian. The matrix in which the fossils occur is a fine-grained ironstone, with small patches of limonite, minute flakes of micaceous iron-ore, and also small, numerous wind-polished quartz grains scattered throughout. Besides the Pectens there are numbers of small fragments of polyzoa present, but indeterminable. These polyzoa are in such abundance as to lead one to infer that the ironstone is largely a replacement of a limestone comparable with the polyzoal rock of Batesford and Grange Burn. This replacement at a later stage, of calcareous by limonitic material seems precisely similar to what has happened in some of the "Gold Drifts" as at Stawell, referred to above, which are to some extent re-sorted or remanié beds, the same characters being also borne by certain of the ferruginous beds of the Mornington Peninsula.

Conclusions

(1) The lower part of the ferruginous series of sandstone and fossiliferous ironstone on the Mornington Peninsula from Frankston southwards is without doubt of Janjukian (Miocene) age.

(2) The fossiliferous ironstone appears to have originated from a more decidedly calcareous rock, and in some cases equivalent to a polyzoal limestone in its included fossils and original chemical composition.

(3) The change from limestone to ironstone has in some cases been brought about by a percolation of dissolved carbonate of iron, causing an interchange of bases, the replaced carbonate of iron afterwards becoming oxidised.

[Proc Roy. Soc. Victoria, 34 (N.S.), Pt. I., 1921].

Art. III.—*The Specific Name of the Australian Aturia and its Distribution.*

By FREDERICK CHAPMAN, A.L.S.

(Palaeontologist to the National Museum, and Lecturer on Palaeontology at the Melbourne University.)

(With Text Figure.)

[Read 12th May, 1921].

The Specific Name.

The unrivalled experience and wide acquaintance of the Tertiary mollusca which my friend, Mr R. Bullen Newton, possesses would naturally forbid me to question his decision that the Australian *Aturia australis* is identical with the European *Aturia aturi*, had it not happened that already I have shown,[1] at least to my own satisfaction, that the species are entirely distinct.

Mr. Newton has recently published[2] an account of a sandstone cast of an *Aturia* from Western Australia, lately acquired by the British Museum, and bases upon this and a comparison of presumably the two specimens recorded from the British Museum collection,[3] a conclusion as to their identity The differences between these forms, the Australian and the European, I have already pointed out,[4] though this seems to have been overlooked by Mr. Newton. These differences are as follows.—

"(1) The Australian shells are more compressed.

(2) The septa and growth-lines are more strongly recurved towards the periphery.

(3) The siphuncular orifice is larger"[5]

In the same paper I also remarked as follows:—

"In view of the above-named characters, which are constant so far as my own observations go, there are justifiable grounds for keeping the Australian form as a distinct species, at the same time bearing in mind that its relationship is nearest *Aturia aturi*. . . . Probably did the London Museum [British]

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1 Proc R Soc Vict, Vol xxvii (N.S), pt. ii., 1915, pp. 350-353, pl. iii., figs. 1, 2.

2. Proc. Malac Soc., Vol. xiii, Oct., 1919, pp 160-167, pl. v.

3 Cat Foss Cephalopoda, Brit. Mus, pt. ii, 1891, p. 355.

4 Loc supra cit., p. 352

5. I find, however, that this is not an invariable character.

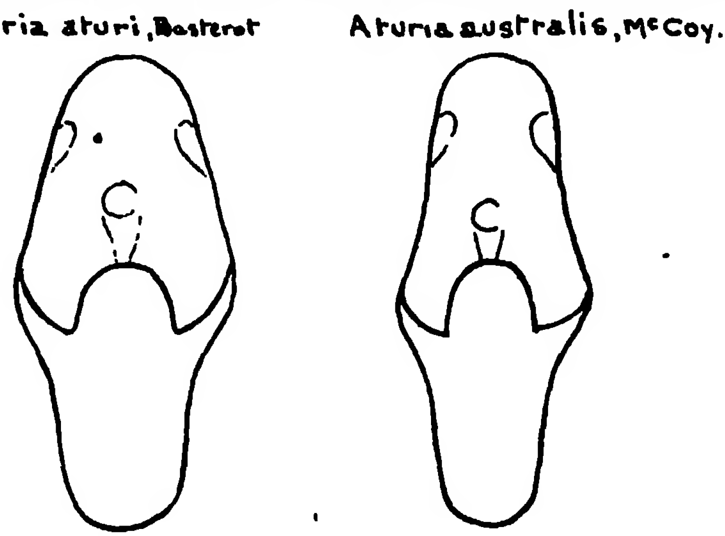
possess a larger comparative series of the Australian form, that view[6] might undergo some modification, and it is to be regretted that Mr. Newton did not have time to critically examine the series of *Aturia* in the Melbourne National Museum."

From a re-examination of the Australian examples I am satisfied that the forms are perfectly distinct, the compressed sides and the generally narrower shell being marked characters of Balcombian, Janjukian and Kalimnan specimens. This feature of the compressed shell is very characteristic of all the southern specimens so far as I have seen, and in some specimens it is developed to an extreme degree. On the other hand the European *A. aturi* tends towards obesity, and an extreme example of this is figured by Bronn.[7]

Hypothesis of Type Origin

From the preceding note of the variations seen in the southern and northern forms it is highly probable that the early (? Lower Oligocene or even Eocene[8]) shells which were ancestral to

ORAL ASPECT OF NORTHERN AND SOUTHERN TYPES.



6. Newton and Cricks' agreement as to the identity of the two forms.
7. Lethaea Geognostica, Vol III., and pl xlii, figs. 17a-c.
8 This earlier stage is suggested on account of the occurrence of large and well-developed shells in the Balcombian of Muddy Creek, one example, found by my son, W. D. Chapman, and now in the National Museum, having a diameter of nearly seven inches.

the already discovered fossils were intermediate in character, and originated in moderately low latitudes, in the Indian Ocean geosynclinal area. The southern form probably radiating to Patagonia, Australia and New Zealand, exhibits variants of compression, whilst that found in Europe tends to inflation. Further data bearing on this hypothesis are furnished in regard to the ratio of shell measurement—umbilical width to diameter. For example, one of the oldest Australian specimens gave a ratio of 1 : 2.91, as against the Bordeaux specimen, 1.2.2; whilst a younger (Janjukian) specimen from Torquay, Victoria gave 1 : 3.26. The Kalimnan specimens are too fragmentary to measure, but bear out this gradually decreasing width ratio.

Distribution of Aturia australis.

Mr. Newton has already given copious notes of the distribution of this fossil in the paper referred to, and it will therefore be unnecessary to repeat them *in extenso*. In New Zealand, we may remark in passing, that *Aturia australis*, though common in the Lower Oamaruian, dies out before the upper beds (Awamoan) are reached. Its geological range in that area seems indeed to be restricted, as was that of *Aturia aturi* in France, Egypt, and elsewhere. Mr. Newton has suggested that the Southern Australian Tertiaries (Balcombian, Janjukian and Kalimnan) represent the Lower, Middle and Upper Miocene, having regard, amongst other data, to the co-extensive range of *Aturia* therein. There are perhaps some points in favour of linking up the lower beds, seeing that at Muddy Creek (Balcombian), both large and small *Lepidocyclinae* are found associated together, as they also are at Batesford (Janjukian), but the evidence requires more support to warrant a re-adjustment of the time-scale.

Comparisons and Limitations of European Stages.

On the evidence derived from a study of the larger Foraminifera, the Balcombian is clearly Aquitanian, so nearly as we can arrive at a correlation of distant sediments. This stage was included by Meyer-Eymar[9] in the Upper Oligocene. Since then Dollfus has favoured the inclusion of the Aquitanian in the

[9] Classification des Terrains tertiaires, 1884 {Aquitanien Upper, Tongrien Middle, Ligurien Lower} Oligocene.

Miocene.[10] The American geologists, Osborne[11] and Chamberlin, as well as Deperet,[12] advocate the position of the Aquitanian as Upper Oligocene. Mainly from the occurrence of the Foraminifera, H. Douville and F. Sacco have in their numerous papers before the Geological Society of France, regarded the large discoidal *Lepidocyclinae* as of Aquitanian age, and the smaller forms of Burdigalian. The genus itself they limit to the Miocene, and therefore they regard Aquitanian as Lower Miocene. Haug, in his studies of geosynclinals also supports these views, regarding the northern Miocene period as one diastrophic whole. We may still hold to the view, however, that great crustal movements did not commence synchronously at the Antipodes.

The sequence of the Lower Tertiary beds in Southern Australia is very gradual, and the sedimentation in one area at least, as shown by the cores from the Sorrento Bore, was never interrupted in that area, but was continuously marine. On the other hand there is a marked unconformity between the Janjukian and Kalimnan, which plainly demonstrates a considerable time-break, and denoted usually by a nodule bed, and we are perforced to mark its distinction from the Miocene as a whole, although, as in *Aturia,* some species range through to the basement Kalimnan.

Referring to the suggestion that the Kalimnan series of Victoria represents the Upper Miocene (Messinian or Pontian)[13] of Europe, by an argument based on the occurrence of *Scaldicetus,* this idea is almost nullified by the fact that this cetacean genus has been lately discovered anew[14] in the Balcombian beds of Muddy Creek (*Scaldicetus lodgei*). Further than this, the presence of the Miocene sharks' teeth in the Kalimnan is accounted for by their occurrence in the basal bed which is often remanié in character.

Summary of Argument.

The writer finds no evidence to justify the identification of *Aturia aturi,* Basterot, with *Aturia australis,* McCoy, and from

10. See "L'Aquitanien on Aquitania," Bull. Soc. Geol. France, ser. 4, vol xii, 1912, p. 472.
11. The Age of Mammals, 1919, p. 224.
12. Transformations of the Animal World. Inter. Sci. Ser., 1909, Table.
13 Newton, Loc cit., p. 166.
14. Proc. Roy. Soc. Vict., Vol. xxx. (N S), pt. i., 1917, p. 34, pl. iv, fig. 6.

a renewed examination concludes that they have distinctive characters of their own which must be regarded as specific.

The suggestion that the Balcombian to Kalimnan Tertiary beds of Southern Australia comprise one period, the Miocene, seems to be untenable from the fact that the succession above the Kalimnan passes upward in sequence, and a new arrangement would mean either an unconformity or the intercalation of a new horizon between the Kalimnan and the Werrikooian to include a Lower Pliocene horizon, which speaking faunistically, is not possible.

[Proc. Roy. Soc. Victoria, 34 (N.S.), Pt. I., 1921].

Art. IV.—*Notes on Amycterides, with Descriptions of New Species, Part III.*

By EUSTACE W. FERGUSON, M.B., Ch.M.

[Read 12th May, 1921]

The following paper contains the descriptions of a few species that have been discovered within recent years. Most of the new species belong to the genus *Sclerorinus;* the members of this genus are often exceedingly difficult of identification, as many, particularly those belonging to Section I., run extremely close to each other, and a knowledge of both sexes is absolutely essential in many cases for identification. For this reason several species represented in my collection by the female sex only are left undescribed.

Within the last two years the veteran entomologist, Dr. David Sharp, has turned his attention to the Amycterides, and is now working on the subdivision of the larger groups, such as *Phalidura, Talaurinus* and *Sclerorinus,* into smaller genera, according to the structure of the male genitalia. One paper has already been published (Entomologists' Monthly Magazine, third series, vol. vi., Jan., 1920, pp. 1-7) dealing with the genera constituting what Dr. Sharp characterises as the tribe *Phaladurines.* This tribe contains the old genus, *Phalidura (Psalidura),* subdivided by Dr. Sharp into *Phalidura* and *Aphalidura,* a new genus—*Prophalidura*—of which *Talaurinus riverinae* is the type, and *Eustatius,* formed for a new species *E. fergusoni.* A table is given of the relation to each other of these four genera. As the change of names affects many Victorian species a few comments may not be out of place.

Phalidura. Genotype—*P. reticulata,* Boisd. (= *P. mirabilis* (Macleay) Fischer, nec Kirby). In the name of this genus Dr. Sharp has revived the original and certainly correct spelling in preference to the emendation *Psalidura* made by Erickson (Agassiz Nomencl. Zool. Col., p. 136), and not by Gemminger and Harold, as stated by Dr. Sharp. In this revival of the name *Phalidura* I am absolutely in accord with Dr. Sharp. Under the genus as defined by Dr. Sharp are included groups

1 and 2 of my revision, and, according to Dr. Sharp, probably most of the other species as far as group 6.

Aphalidura. Genotype—A. *impressa,* Boisd. Included with this are *P. sloanei,* Ferg., and *P breviformis,* Ferg.. *P. sloanei,* Ferg., is certainly congeneric with *P. impressa,* Boisd., and if the genus *Aphalidura* is to be recognised all the members of group 7 should be included. I am much more doubtful about the species of group 9, of which *P. breviformis,* Ferg., is a member, and there seem equally good reasons for separating all the groups generically as for splitting off groups 7 and 9 For the present, therefore, and until much more work is done on the male genitalia and abdominal segments of the various groups, I think it would be better to restrict the new genus to group 7. For this reason, in describing a new species of group 9 in the present paper, I have thought it better to place it under the old genus *Phalidura.*

A further difficulty arises in connection with the name of the genus. *Phalidura impressa,* Boisd, the type of *Aphalidura,* is almost certainly the original *Curculio mirabilis,* Kirby, or as Sharp says, possibly a close ally of it. The key to the solution lies in the interpretation of the figure of the male sexual mechanism given by Kirby. As Dr. Sharp points out, the figure is not satisfactory for *P impressa,* though the discrepancies may be partially, if not wholly, due to foreshortening I believe that this is probably the case as in all the allied species known to me the apices of the laminæ are broadly rounded, and not obtusely pointed as in *P. impressa,* and in the figure of *C. mirabilis.*

I have to thank Mr. Sloane for drawing my attention to the fact that Erickson, as early as 1842 (Archiv. für Natur, p 113) identified *P. mirabilis,* Kirby, with the only known Tasmanian species, and in a footnote gives *A mirabundus,* Gyll, as a synonym, while drawing attention to (?)Schönherr's misidentification of *P. mirabilis. A. mirabundus,* Gyll.' (1834) antedates *A. impressus,* Boisd. (1835), the type of which was also from Tasmania.

If *Curculio mirabilis,* Kirby, is to be thus identified with *Amycterus impressus,* Boisd., the further question arises as to whether the name *Amycterus* should not be used in preference to *Aphalidura* for this group. *Amycterus'* was described in Schönherr's *Curculionidum Dispositio Methodica,* 1826, p. 202, the type of the genus being given as follows:—

Typus. *Curc. mirabilis*, Kirby, in Linn. Trans.—Species unica e nova Hollandia, magna, facie aliena, rostri forma insolita et valde singulari.

This absolutely fixes the name *Amycterus* to the species described by Kirby, and is not affected by the fact that Gyllenhal, in 1834, in re-describing, from the Schonherr collection, *Amycterus mirabilis*, described the gular-horned species previously described by Fischer (1823) as *Phalidura mirabilis* (= *P. reticulata*, Boisd.).

If, therefore, group 7 is to be separated generically from *Phalidura*, the name *Amycterus*, which I have, in an earlier paper, placed as a synonym of *Phalidura*, must be revived and used in preference to *Aphalidura*, Sharp.

I have gone into this question at some length, as the change of names will affect most of the Victorian species now called *Psalidura*.

Prophalidura. The type species is *Talaurinus riverinae*, Macl., and a second species, *P. truncata*, is described. This I have not been able to identify. The limits of the genus are somewhat uncertain, but, as characterised, would probably exclude many species such as *tomentosus*, *howitti*, *maculipennis*, etc., which show a decided resemblance to *riverinae*. One species,—*T. granulatus*, Ferg.—should, I think, be referred to *Prophalidura*.

Eustatius fergusoni, Sharp. Both genus and species are unknown to me; it is probably a good genus, but the distinction as regards the short forceps is hardly sufficient to separate it from *Phalidura*, as equally short forceps occur in several species of that genus.

Boisduvalian Types of Amycterides.

In a previous paper (Proc. Linn. Soc., N.S. Wales, 1911, xxxvi., p. 141), I re-described such of Boisduval's types of Amycterides as were in the Dejean collection, now in the Brussels Museum. A few types described from other collections were not seen, and while in Paris I endeavoured to trace the whereabouts of these, and in particular of those belonging to the collection Dupont. In the Museum National d'Histoire Naturelle at Paris I examined the types of *Talaurinus tomentosus*, Boisd., and *Euomus scorpio*, Boisd., both of which are correctly identified in Australian collections.

A specimen of *Acantholophus aureolus*, Bohem., in the museum was marked as the type of *Acantholophus echinatus*, but whether it is the type of Guerin's or Boisduval's species of that name I am uncertain. The question is fully discussed elsewhere; it is to be noted, however, that none of the types of other species described by Guerin are in the Museum.

At the time I could get no certain information in regard to the types from the Dupont collection, but later received a letter from M. Lesne, of the Museum, from which the following passage is quoted:—

"Pour ce qui est de la collection Dupont, mes souvenirs étaient inexacts. Les Curculionides de cette collection avaient été cédés à Jekel. Ils sont passés ensuite dans la collection Bowring qui est conservé aujourd'hui au British Museum."

On receipt of this information I wrote to Mr. G. F. Arrow, of the British Museum, and received the following reply: "We had no idea any of Boisduval's weevils were in our collection, but have found specimens with "Dup." in Jekel's writing, so no doubt Lesne is right. Jekel seems to have systematically removed all original labels, replacing them only with a number, of which we have no explanation. There are Bowring specimens of *rugifer*, *basalis*, etc., which are very likely types, but I can find no positive evidence in any case. As it is more than 50 years since the Bowring collection came here it is likely that some specimens have been parted with, or even destroyed as worthless."

The species affected are as follow, placed in their proper genera: *Talaurinus rugifer, Sclerorinus tristis, Macramycterus boisduvalii, Mythites basalis,* and the species described as *Amycterus posticus,* which I am not able to place generically. With the exception of the last, the names of these species have been attached to well known species, which agree very well with the original descriptions.

Types of Amycterides in the British Museum.

While in London I was able to examine the types of Amycterides contained in the British Museum collection. Notes on some of these have already been given, or they will be dealt with in their places in the revision of the subfamily, this in particular applying to the Euomid genera.

The following notes may be recorded here:—

Talaurinus phrynos, Pasc.—This is certainly a female *Phalidura*, and practically certainly the female of *P. forficulata*, Macl., from the same locality—Rockhampton.

Talaurinus victor, Pasc.—The type is a female of T. *caviceps*, Macl.

Talaurinus carbonarius, Pasc.—Good species; type is a female.

Talaurinus inaequalis, Blackb. and *Talaurinus strangulatus*, Blackb. Closely allied species, differing in the more excavate rostrum of *T. strangulatus*

Talaurinus pustulatus, Pasc.—The common Western Australian species—*T. semispinosus*, Bohem.

Talaurinus simulator, Pasc.—Type a ♂, with more acute tubercles than in the specimens identified by Blair. Unfortunately none of these specimens were available for comparison, but I think that probably they are correctly placed.

Sclerorinus echinops, Pasc.—As previously recorded (These Proceedings, 1915, p. 243), this species belongs to Talaurinus (sens. lat.), and is closely allied to *T. semispinosus*, but a distinct species; type is a female.

Talaurinus funereus, Pasc.—Type appears to be a somewhat abnormal female of *T. roei*, Bohem, with tubercles rather obsolete at base, and fewer than usual

Talaurinus lemmus, Pasc. *(Pseudonotonophes)*.—The head of type is non-granulate.

Talaurinus pupa, Pasc *(Pseudonotonophes)*.—The head of type is distinctly granulate. This species is the same as *P. dumosus*, Macl.

Sclerorinus molossus, Pasc.—Type is a female; tubercles black, otherwise the same as specimens so identified in my own collection.

Sclerorinus molestus, Pasc.—Considerable variation exists among specimens referred to this species; the following brief notes made on the type are therefore reproduced: "Type ♂. Ventral vitta tawny. Prothorax broadly dilatate, set with small, rather depressed granules, with granules on sides much smaller and obsolete towards coxæ. Elytra with granules small, equal in size on all the rows, 5, 16, 5, 16, 14 in number on the interstices of left side.

Sclerorinus taeniatus, Pasc.—Type is a male, and the same as *S. stewarti*, Macl.

Opetiopteryx frigida, Blackb.—Vide infra.

Portion of the Amycterides of the Hope Collection (Oxford) were at the British Museum, and I was able to examine the types of the following species:—

Acantholophus hystrix, Bohem.—As identified in Australia.

Hyborrhynchus coenosus, Bohem.—As identified in Australia ♀.

Cubicorrhynchus bohemanni, Bohem.—As identified in Australia ♀.

Cubicorrhynchus scotobioides, Hope M.S.—*C. bohemanni* ♂

Talaurinus westwoodi, Bohem.—*T. bucephalus*, Oliv

Talaurinus gyllenhalli, Hope M.S—*T. bucephalus*, Oliv.

Talaurinus excavatus, Bohem.—*T. rugifer*, Boisd.

Talaurinus semispinosus, Bohem.—As identified in Australia.

Talaurinus pastillarius, Bohem = *T. semispinosus*, Bohem. It is doubtful whether this specimen is the type

Talaurinus roei, Bohem—*T. funereus*, Pasc. is a synonym.

Sclerorrhinella manglesi, Bohem.—As identified in Australia.

OPETIOPTERYX FRIGIDA, Blackb.

Blackburn, Proc. Linn Soc. N S. Wales, vii., 1892, pp 125, 126.

I am unable to follow Blackburn in placing this species among the Amycterides. The general facies is much more like *Polyphrades*, and the shape of the rostrum and scrobes quite unlike any Amycterid. The tarsal joints are much more expanded than in any Amycterid known to me, and the funicle is 7-jointed.

The species must be rejected from the Amycterides, but its position is doubtful. Possibly it is allied to *Bothynorrhynchus*, which was placed by Lacordaire in the Somatodides.

PHALIDURA AFFINIS, n sp.

Closely allied to *P. elongata*, Macl., but with more widely separated fascicles.

♂ Black; moderately densely clothed with minute yellowish-brown subpubescence, feebly variegate with grey; setæ yellowish-brown.

Head and rostrum as in *P. elongata*; the internal dorsal rostral ridges slightly more prominent, and the median area feebly car-

inate. Prothorax and elytra as in *P. elongata,* except that the intrastrial granules on the elytra are less evident.

Venter as in *P. elongata;* the apical excavation of the same shape, but with the fascicles slightly larger, and distinctly farther apart Forceps apparently slightly shorter, the laminæ similar in shape.

Dimensions —♂ 22×8 mm.

Hab —Queensland Type in Queensland Museum. This species might be better regarded as a geographical race, or subspecies of *P. elongata* The three males before me all agree in the shape and position of the fascicles, which are constantly wider apart than in *P. elongata.* I have seen numerous examples of the latter species, and they all agree in the closely approximated fascicles. It seems to me, therefore, that the Queensland form is worthy of a distinguishing name. No locality labels are present on the specimens.

Associated with the three males are seven females, which probably belong to the same species, but the lack of locality labels does not permit of absolute certainty, as the females of several allied species are practically indistinguishable

PHALIDURA HOPSONI, n sp.

Allied to *P. variolosa* and *P irrasa*, but differing in the genitalia of the male

♂ Black, sparsely clothed in depressions, with minute greyish subpubescence; setæ dark.

Head convex, setigeropunctate; with a median, longitudinal impression anteriorly. Rostrum about as wide as head, width across external ridges about one-half the total width; upper surface deeply excavate anteriorly, with basal foveæ narrow, triangular but deep, and a median fovea separating the ends of the internal ridges Eyes ovate, rather larger and less deeply set than in *P irrasa.* Antennæ with scape shorter and somewhat stouter than in *P. irrasa.*

Prothorax as in *P. variolosa;* set with similar setigerous granules; median impression most distinct posteriorly.

Elytra as in *P. variolosa;* punctures open foveiform; interstices set with small setigerous granules, in single series, duplicated on the third and fifth interstices

Apical ventral excavation deep, praeanal fossa not very sharply marked off from rest of excavation; fascicles black,

rather widely separated; apical margin with a fringe of black bristles, closely set with an intermediate row of similar bristles, so that the two rows are hardly separable. Forceps short, stout at base, ending in an obtuse point, apices not meeting; laminæ more strongly convex, and less elongate than in *P. irrasa* and *P. variolosa*, more or less concealed by a thick brush of hairs projecting between the bases of the forceps, and apparently arising from the last dorsal segment.

♀ Resembles the females of the allied species, but antennal scape shorter.

Dimensions.—♂ 17×8 mm.—14 5×6 mm.; ♀ 15×6 mm.

Hab.—New South Wales, Barrington Tops (H. J. Carter), Eccleston (J Hopson).

The genitalia is similar to that of *P. variolosa* and *P. irrasa*, but differs from both in some features. The bristles on what I have previously termed the intermediate row, and on the apical margin, are closely applied, and difficult to distinguish from one another; they are obviously shorter than in *P. variolosa* and *P. irrasa*, and apparently both sets cross the middle line. The bristles on the last dorsal segment form a very conspicuous brush, projecting between the blades of the forceps, which are shorter, and do not meet at the apex. Type in author's collection.

TALAURINUS ANTHRACOIDES, n.sp.

♀ Allied to *T. tenebricosus*, Ferg., but larger, with rougher sculpture.

Black, practically destitute of clothing; setæ black

Head convex, rather feebly depressed in front at base of rostrum; eyes small, rotundate Rostrum short, almost as wide as head; external margins raised into subparallel ridges, running back to head, but not continued along forehead, moderately closely setigero-punctate; upper surface excavate, internal ridges distinct, little convergent, sublateral and basal foveæ forming a horse-shoe shaped impression at base. Antennæ moderately long, scape stout, funicle with joints short, the first somewhat longer than the second.

Prothorax rounded on sides, widest in front of middle, apex with median and ocular lobes widely rounded and little prominent; disc convex, without impressions, closely set with small, round, subcontiguous granules; sides also granulate.

Elytra evenly rounded on sides, apex hardly produced, widely rounded; base feebly emarginate, humeral angles with a small nodule; disc with punctures rather large, open, not distinctly separated from one another; interstices hardly raised, closely set with small round setigerous granules, in single series, occasionally duplicated in middle of third and fifth, and extending down declivity; sides granulate. Venter convex; apical segment with a median longitudinal impression in posterior half, with a transverse sulcus at extreme apex. Legs simple.

Dimensions.—♀ 17 × 7 mm.

Hab.—Victoria, Trawool, Kerrisdale (J. E. Dixon).

Described from three females received from Mr. J. E. Dixon. I have departed from my usual plan of describing only when the male is known, as in this case it does not seem likely to be confused with any other species.

I regard it as allied to *T. tenebricosus*, the rostral structure and general appearance are similar, but the present species is decidedly larger, and the granules much more evident. After the description of the female was written, and when the manuscript was practically complete, I received a somewhat broken specimen of the male, taken by Mr. Dixon in the same locality.

Allotype ♂.—Similar to female, apex subtruncate, with rather thick granulate flanges on each side, separated in the mid line by a small notch. Legs simple. Ventral segments flattened, the intermediate ones rather short, the apical strongly concave, deepest along the posterior margin; ventral surface of apical dorsal segment also concave; ends of forceps visible at sides of excavation. Dimensions.—♂ 16 × 6 mm.

I have endeavoured to dissect out the genitalia, but found that unfortunately most of the internal structures had disappeared. The eighth ventral segment was, however, represented by a pair of well developed strongly chitinised forceps, the apices of which project externally. The inner surface is curved inwards towards the base to form a strong process extending almost to the mid line, but apparently there is no fusion of the processes of the two blades, though, as this portion is broken, it is impossible to be sure, and it is likely that the gap was bridged by chitin, as there is a small mass adhering at one side. In the allied species *T. tenebricosus*, the forceps are very similar in shape, though smaller and the inner ends are connected by chitin, the segment furthermore possessing another flat plate of chitin anterior to the bar between the inner processes of the forceps;

there is however no vertical plate as in *Prophalidura,* and the species can hardly be placed in that genus as at present defined If the characters of the eighth ventral segment are to be regarded as of generic value many new genera will be necessary, at present and until much more work can be done on the dissection of these species, I think it inadvisable to erect isolated genera, and prefer to place the species under *Talaurinus* in the Macleayan use of the genus

NOTONOPHES DILATATICEPS Blackb

Cubicorrhynchus dilataticeps, Blackb, Report Horn Exped Central Australia ii, 1896, p 293, Ferguson, Proc Linn Soc N S Wales 1914 xxxix p 224, *Notonophes auriger,* Ferg, loc cit p 222

In my revision of the genus Notonophes I referred *Cubicorrhynchus dilataticeps* Blackb, there I have since examined the type in the British Museum, and it is certainly a species of *Notonophes* and evidently the same as *N auriger* Ferg, although a specimen of the latter was not available for comparison

SCIEROKRHINELLA CRAWSHAWI, sp n

Allied to *S granuliceps* Ferg, but larger, with smaller less regular granules

♀ Black, densely clothed with fine white decumbent pubescence, head with a broad stripe of dark brown on each side of median line prothorax with an ovate brown patch on disc, not reaching apex and bisected by a median white vitta, a fainter brown stripe at lateral margins, elytra with scattered, irregular, brown macules, venter more sparsely clothed the basal segments practically without clothing except at sides legs densely clothed with white

Head convex front somewhat flattened and set with small, slightly depressed separate granules the vertex and sides not granulate Rostrum short and broad, lateral margins not raised, slightly convergent to base, setigeropunctate, median area lævigate, trianguliform depressed in front, basal sulci rather broad, internal ridges absent Antennæ of moderate length, funicular joints short, the first longer than the second

Prothorax evenly rounded on the sides, apical margin with rather feeble post-ocular sinuation, disc convex, closely set with small, round granules, smaller on median vitta, the granules

completely clothed, and less conspicuous on the areas covered with white pubescence, but incompletely covered on the brownish clothed areas; sides granulate.

Elytra robust; apex widely rounded; base gently emarginate, humeral angles noduliform; strial punctures shallow, open, transverse; interstices little raised, set with very fine granules, more or less concealed by the clothing, somewhat variable in size, set in rather irregular single series, duplicated in places, absent on apical half of fourth interstice and on declivity; granules obsolete on lateral interstices. Venter convex, with fine scattered setigerous punctures. Legs simple.

Dimensions.—♀ 17 × 7 mm

Hab.—Western Australia, Jandakot (W. Crawshaw).

Three specimens of this fine species are before me, all females, but I have had no hesitation in describing the species, as it is quite distinct from the other known members of the genus. The species is apparently most closely allied to *S. granuliceps*, Ferg., but differs in the finer, less regularly arranged, granules on both prothorax and elytra I have much pleasure in naming this species after its discoverer

Type in author's collection

SCLERORINUS DAVEYI, n sp

♂ Moderately large, elongate Black; moderately densely clothed with dark brown depressed pubescence; head and prothorax rather feebly trivittate, with lighter creamy clothing, elytra with feeble traces of light clothing about shoulders

Head flattened in front, in the same plane as, and not separated from dorsal surface of rostrum. Rostrum with external margins parallel; median carina distinct, with a small puncture at junction with head; sublateral sulci broad, rather shallower than in *S. oblongatus*. Mandibles with inner edge produced apically into a somewhat obtuse point, variable in shape, or absent on one side.

Prothorax strongly rounded on the sides, apical margin with strong postocular lobes, and feeble median lobe; disc with subapical constriction moderately marked, and with median line shallowly but distinctly impressed; rather remotely set with elongate subobsolete setigerous granules, practically only distinct between median and sublateral vittæ; sides without granules.

Elytra elongate, subparallel; base gently emarginate; humeral

angles subtruncate; disc with punctures open, shallow, not very distinct; interstices slightly raised, the third and fifth more so than the others; with slight tuberculiform elevations at irregular intervals, the second interstice with 5; the third with 8-9 indicated, the basal ones hardly more elevated than the interstice, which is here subcostiform, the apical ones small, granuliform, but more distinct, extending half-way down declivity; fourth with 3-4 small tubercles; fifth subcostiform the individual tubercles only indicated by setæ, somewhat more distinct posteriorly; sixth with a continuous row of small separate granuliform tubercles; seventh and lateral interstices with tubercles obsolete. Venter somewhat flattened along middle; apical segment with posterior margin strongly bisinuate, the median portion produced as a rounded lobe, somewhat depressed. The last dorsal with undersurface emarginate to correspond with projection of apical ventral segment. Legs not notched; anterior tarsal joints asymmetrical, but less markedly so than in some of the allied species.

♀ Agrees with male; elytra somewhat more ovate; venter convex, apical margin produced ventrally but not bisinuate, with a small emargination at extreme apex, filled with a few stout setæ.

Dimensions — ♂ 16×6 mm.; ♀ 16×6 mm.

Hab.—Victoria, Portland District (H. W. Davey and J. E. Dixon).

I am indebted to Mr. H. W. Davey for a series of this species.

A female given me by Mr. J. E. Dixon differs in being larger (17×8 mm.), and in the much lighter clothing; the head and prothorax are conspicuously trivittate with white, while the median line of elytra, and much of the lateral portions of the disc are covered with similarly coloured clothing The sculpture is much as in the type, except that the tubercles are slightly larger; the apical ventral segment is lightly impressed in the median line, and the apex is as described.

S daveyi belongs to a group of closely allied species, for whose correct determination a knowledge of both sexes is necessary; thus the present species is close to *S. inornatus*, from the ♂ of which it can only be distinguished by its less obliterate sculpture, whereas the two females are abundantly distinct.

SCLERORINUS SLOANEI, n.sp

♂ Elongate, subparallel. Black; sparsely clothed with minute brown subpubescence; setæ dark brown.

Head convex, forehead somewhat flattened, in same plane with dorsal surface of rostrum; feebly longitudinally impressed on each side of median line, with two small linear foveæ in median line, one in centre, and one at junction with rostrum. Rostrum subparallel, the median carina as distinct as the external ridges, all three carried back on to head; sublateral sulci moderately broad, deeper at base. Antennæ comparatively short, moderately stout, first funicular joint longer than second.

Prothorax rounded on sides, broadest in front of middle; apical margin hardly produced above, feeble emarginate in middle, with fairly evident ocular lobes; subapical constriction moderately marked, median line lightly impressed, disc set with subdepressed, elongate, irregular sub-confluent granules, becoming smaller and more rounded at sides; lateral surfaces with small scattered obsolescent granules.

Elytra elongate, subparallel, apex rounded; base gently emarginate, humeral angles not tuberculate; with rows of small, well defined foveiform punctures, each subtended by a small seta; the first, third and fifth interstices raised, with elongate somewhat flattened tubercles, less elongate towards apex of elytra, with small setæ at the posterior end; second and fourth interstices neither raised nor tuberculate; sixth and seventh with less elongate tubercles; lateral interstices without definite granules or tubercles. Venter subnitid, set with black, decumbent setæ; depressed at base, lightly transversely convex on intermediate segments; apical segment slightly depressed with a median longitudinal sulcus bounded posteriorly by a less defined transverse impression, the lips of the median sulcus raised in a small projection above junction with the transverse impression; apical margin evenly rounded, not bisinuate. Legs simple; anterior tarsi symmetrical.

♀ Similar to male; prothorax with granules more rounded, less elongate; elytra more produced, the apex strongly bimucronate, tubercules fewer and more spaced out on second interstice. Venter strongly convex, apex rounded, not bisinuate.

Dimensions.—♂ 17×6 mm.; ♀ 17×6.5 mm.

Hab.—N.S. Wales, Capertee (T. G. Sloane and H. J. Carter).

Described from one male and three females, all of which agree in having no tubercles on the second and fourth interstices.

Associated with these, and from the same locality, are four males and a female, which differ in having elongate, spaced out tubercles on the second and third interstices, the sutural interstice is also less raised, except at base, while the punctures are less regular. I can see no other difference except that the prothoracic granules are less elongate.

I am undecided whether these represent a distinct species, or are merely individual variations; I am inclined to the former view, but have thought it better not to affix a name to the specimens while doubt exists as to their status.

The dimensions of these specimens with the number of tubercles on the second and fourth interstices vary somewhat, and are given in the following table:—

Sex	Dimensions	Second Interstice	Fourth Interstice.
♂ . . .	16 × 5.5 mm. ..	6—8 ..	5
♂ . . .	15 × 5 „ ..	2 ..	4—5
♂ . . .	17· × 6 5 „ ...	4—5 ..	5
♂ . .	18 × 7 „ ..	2—3 ..	3
♀ . . .	17.5 × 7 „ ..	4 ..	3—5

SCLERORINUS MELICEPS, Pasc.

Pascoe, Journ. Linn Soc. 1873, p. 10; Ferguson, Proc. Linn. Soc N S Wales, 1915, xl, p. 801.

When in London I had an opportunity of examining the type ♂ of this species in the British Museum, and made the following notes:—

"*Sclerorinus meliceps*, Pasc. ♂ (Type), belongs to subcostatus group and allied to *S. squalidus*. Prothorax with small round granules, abraded in centre. Elytra with depressions irregular, transverse, not deep; granules prominent, about equal in size to interstitial granules; these granuliform forming continuous rows on the third, fifth and sixth, at intervals on the second and fourth, hardly distinguishable from the other granules. Median vitta yellow. Middle tibiæ notched. Setæ yellow."

Hab.—Queensland.

This species was unknown to me at the time I revised the genus, and provisionally it was placed in group V. It should however come into group IV, and next to *S. squalidus*, Macl.

SCLERORINUS BESTI n sp

A small species in general appearance resembling the tuberculosus germari group but with simple intermediate tibiæ

♂ Black densely clothed with dark brown minute subsquamose pubescence vittate with creamy head with a median vitta bifurcate on rostrum prothorax and elytra trivittate the inner surfaces of the tubercles also with lighter clothing lower margins of elytra vittate with creamy venter with yellowish brown macules in mid line and with black hairs on apical segment only

Head convex running into rostrum without any definite line of demarcation Rostrum with external ridges subparallel running back on to head somewhat broader posteriorly median area lævigate raised carinate sublateral sulci elongate deeper posteriorly Antennæ rather short scape stout funicle with joints short first slightly longer than second Eyes ovate

Prothorax subangulate on sides widest across middle apical margin rounded above produced somewhat over head with definite ocular lobes subapical constriction rather strongly marked, median line free from granules but not definitely impressed disc set with comparatively large rounded granules rather distantly placed and absent along median and sublateral vittæ sides with indications of granules in front Elytra elongate gradually widened to behind middle apex widely rounded base emarginate humeral angles with a large somewhat obtuse tubercle punctures small and obscure except between second and third rows of tubercles where they are distinct with three rows of strong conical tubercles first interstice with a row of granules second interstice with a row of 6 7 tubercles elongate anteriorly but not extending to base larger and more acute posteriorly and extending half way down declivity third interstice with 6 8 similar tubercles but starting from base and ending on edge of declivity fourth without tubercles fifth with a short row of 4 small tubercles including humeral tubercle followed almost in the same line by 5 large tubercles on the sixth interstice lateral interstices with a few depressed granules Venter flattened apical segment concave the sides produced ventrally with an acute angle somewhat incurved posteriorly the centre of the concavity occupied by a brush of thickly set hairs the lateral portions more deeply excavate Apex of last dorsal segment narrow but rather strongly setigerous Legs simple intermediate tibiæ not notched

♀ Similar to ♂, but more rounded on elytra; elytral tubercles similar, but a subapical tubercle present on one side in the only ♀ before me. Ventral segments convex, apical segment not excavate, but with a small round depression at extreme apex.

Dimensions.—♂ 12×4 5 mm.; ♀ 12×5 mm.

Hab.—Victoria, Portland (J. E. Dixon).

Although undoubtedly a *Sclerorinus* as that genus is at present understood, I am undecided to what group to assign the present species. It is referred to Section II. with some doubt as the median vitta is incomplete, being practically only represented by the long hairs on the apical segment, this segment is however not channelled as in Section I. The tubercles of the fifth interstice would place it in Group V., and it has a resemblance to the *tuberculosus-germari* portion of the group, but the tibiæ are simple, and it bears little likeness to the rest of the group. The structure of the apical ventral segment is quite unlike that of any member of the fifth group, but is similar to that found in Group II., but the members of this group are otherwise very different

I am indebted for four specimens (3 ♂♂, 1 ♀) to Mr. J. E. Dixon, and have much pleasure in naming the species after his friend and fellow-collector—Mr. D. Best, of Melbourne.

Types in author's collection.

[PROC. ROY. SOC. VICTORIA, 34 (N.S.), PT. I., 1921].

ART. V.—*New Australian Coleoptera with Notes on some previously described Species, Part I.*

BY F. ERASMUS WILSON.

(Communicated by J. A. Kershaw.)

(With Text Figure.)

[Read 9th June, 1921]

BYRRHIDAE.

PEDILOPHORUS VENUSTUS, n.sp.

Head and prothorax brassy, with a purplish tinge; elytra bright metallic green, under surface reddish-fuscous; appendages paler. Portions of upper surface glabrous, but in parts clothed with a dense semi-decumbent golden pubescence, forming definite patterns, this interspersed with much longer and more erect dusky hairs; under surface and all appendages with paler pubescence.

Head widely rounded in front, with dense and sharply defined punctures. Antennæ with joint 1 very stout, and darker than the following ones; 3 thin, and a little longer than 2; 4, 5, 6 subequal; 7 somewhat transverse; 8, 9, 10 strongly transverse, and with 11 forming a stout club; 11 viewed from above pointed, and about twice the length of 10; viewed from the side, however, it is seen to be bluntly rounded. Prothorax strongly convex, sides near base quite vertical; punctures as on head. Scutellum small, punctured. Elytra strongly convex, sub cordate, punctures very much fewer and sparser than on prothorax. Epipleurae narrow, terminating at hind coxae, with a few ill-defined punctures. Under surface heavily punctured, except on disc of metasternum, where they are much finer and sparser.

Length.—3, breadth 2, mm.

Habitat.—Victoria: Fern Tree Gully, Warburton (F. E. Wilson).

Compared with a co-type of *P. raucus*, Blackb., the present species differs in being much smaller, colouration different, elytra, disc of metasternum and legs, with very much finer and sparser

punctures, and clothing forming distinct patterns. These patterns however may easily lose their symmetry where a specimen has become greasy. Four specimens were secured at Fern Tree Gully, and six at Warburton by sieving damp moss collected from treefern trunks and old logs.

Type in author's collection.

PEDILOPHORUS GLOBOSUS, n sp.

♂ Reddish-brown, becoming darker in places, glabrous, nitid. Legs, palpi and two basal joints of antennæ fuscous, rest of antennæ darker; antennæ finely pubescent, clypeus with a few longer hairs. Under surface and legs clothed with very short pale pubescence, densest on apical ventral segment.

Head rather large, with somewhat sparse, but well-defined punctures, fairly uniformly distributed; antennæ moderately long; joint 1 very stout; 2 thinner, and decreasing towards apex; 3 much thinner, and approximately equal to the three following combined; 4, 5, 6 slightly decreasing in length; 7 rounded; 8, 9, 10 transverse, and forming with 11, which is stout, and bluntly pointed, a well defined club. Prothorax smooth, strongly convex, almost twice as long as broad, rounded in front, and evenly decreasing in width from base to apex; lateral margins narrow. Scutellum apparently wanting. Elytra smooth, very convex, almost continuous with outlines of prothorax; epipleurae very broad to about hind coxae, then becoming abruptly, but evenly narrowed down to their termination just beyond base of apical ventral segment Under a high power the abdominal segments appear to have fairly numerous shallow transverse depressions on their surface, this being not so noticeable on the apical segment.

Length:—1.5 mm.

Habitat.—Victoria. Warburton, near the summit of Mount Donna Buang, Fernshaw (F. E. Wilson).

In the type and one other specimen the ♂ sexual organs are well exserted, and consist of a fairly long, parallel-sided penis, on either side of which are two acutely pointed horny processes.

When highly magnified a very obscure transverse row of dark spots can be discerned on the prothorax, just above the basal margin. One specimen of the twelve under examination is almost quite black, the others being coloured as in the type. This species comes nearest to *P. atronitens*, Lea, but may be

easily distinguished from that species by its glabrous upper surface, less distinct cephalic punctures, and in having a club composed of 4 joints only as against 5 in *atronitens*. All my specimens were secured from damp moss, collected from old logs during the month of April.

Type in author's collection.

PEDILOPHORUS RAUCUS, Blackb.

Byrrhus raucus, Blackb., Trans. and Proc., Roy. Soc. S. Aust., xiv., 1891, p 133.

I am not aware of any previous record of members of the genus *Pedilophorus* being associated with ants, practically all the known species having been taken either in moss or in flood debris. Whilst I also have taken *P. raucus* in moss, I have to record the finding of sixteen specimens in a single nest of a small ant at Lakes' Entrance.

My friend, Mr. C Oke, has also collected from ants' nests at Bacchus Marsh specimens of a Pedilophorus which I believe to be this species, although I have not had an opportunity as yet of carefully examining his material.

EROTYLIDAE.

EPISCAPHULA RUFOLINEATA, n. sp.

♂ Black, nitid, all markings yellowish red; apex, sides and about half base of prothorax margined by a moderately broad band; prothorax subequally divided into four zones by three irregular longitudinal stripes starting from the front marginal band, the centre one falling a little short of the basal margin, the two outer ones joining the basal marginal band; each elytron with a stripe bordering about half the base, and continuing around the scutellum a short distance down suture; an irregular fascia beginning near suture at about one-third, and meeting at outer edge a narrow marginal stripe starting from shoulder, the latter passing a little beyond its juncture with fascia; a somewhat irregular stripe beginning near apex, passing up near suture, then gently curved outwards, meeting margin at about two-thirds, from whence becoming attenuated, it returns along the margin to apex; all appendages castaneous except club of antennæ, which is black.

Head moderately distinctly punctured on clypeus, more sparsely elsewhere; eyes widely separated from scape by a

rounded outward projection of head Prothorax about one-third wider than long lightly but frequently punctured except on the side margins which are almost impunctate and in the shallow depressions on either side of base where there are a few well defined larger punctures Elytra faintly punctured punctures tending to arrange themselves in series this most pronounced near suture On the pale markings there are a few black spots which also suggest being placed in longitudinal series Scutellum strongly transverse Prosternum with punctures fairly numerous except on intercoxal projection on the outer edge of which there are several shallow longitudinal sulci Mesosternum lightly metasternum more heavily punctured the latter also with a well defined longitudinal sulcus on disc

Length —7 5 breadth 3 5 mm

Habitat —Queensland Mt Tambourine (A M Lea and H Pottinger) Blackall Ranges (F E Wilson) National Park (H Hacker)

The ♀ may be distinguished by its much shorter antennæ and legs and its considerably less dilated front tarsi

Some specimens are somewhat larger than the type and the elytral markings are more or less variable Specimens from Mount Tambourine are all very similar but two from Blackall Ranges and one from the Queensland National Park exhibit the variation as shown in figure B figure A representing the markings of the type

Type in author s collection

Fig A

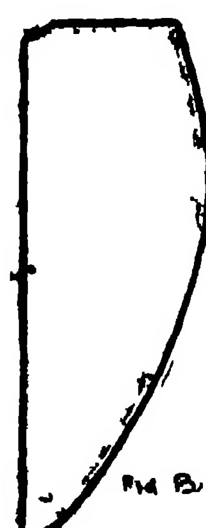


Fig B

STAPHYLINIDAE.

MEGALOPS MELBOURNENSIS, n. sp.

Upper surface, with the exception of elytra, and the flavous apex of sixth visible abdominal segment, jet black; elytra red, the whole highly polished; antennæ with joints 1-8 testaceous, 9-11 black. Femora and tibiæ dark, but with their bases and apices paler; tarsi and palpi flavous, mandibles becoming paler at their apices. Under surface with mouth parts, gular, a border around metasternum, and trochanters testaceous, the rest black, and the whole nitid.

Head subtriangularly produced in front, with very large foveate punctures, except at apical margin and on disc; eyes finely faceted; antennæ with joint 1 cylindric, thick, 2 thinner and nearly equal to the three following combined, 3-8 moniliform, 8 somewhat longer than the preceding one, 9-11 forming a very conspicuous club, joints 1-8 with a few setae, 9-11 rather strongly pubescent. Prothorax about as long as broad, sides produced into a blunt tooth just above basal half, and again between that point and apex, strongly convex, with irregular punctures as on head, punctures tending to arrange themselves in circular series; unpunctured spaces somewhat raised. Scutellum small, truncate behind, with two large foveate depressions in middle. Elytra about the length of prothorax, subsutural striae well defined, disc of each elytron with two wide, deep, obscurely punctate striae, which neither attain the base nor apex of elytra; midway between these and the lateral border are a few large irregular punctures arranged longitudinally; near apex of each elytron at sutural angle are a few irregular indistinct striae. Abdomen narrower than elytra; arranged across basal halves of each segment are a series of large shallow depressions, these becoming less distinct on apical segments; apical declivity of each segment with several transverse rows of fine lines; lateral margins of abdomen with sparse decumbent pubescence. Under surface with prosternum punctured as on pronotum, metasternum with a few smaller setigerous punctures on disc only, abdominal segments with somewhat similar punctures arranged transversely.

Length, 3.75 mm.

Habitat.—Victoria: Melbourne (F. E. Wilson and Ejnar Fischer), Noble Park, Preston (F. E. Wilson).

This species may be readily distinguished from *M. nodipennis*, Macl.,[1] by its different colouration, its much more even prothoracic surface, and the absence of the nodular excressences on the elytra, which is so characteristic a feature of that species.

My friend, Mr. Fischer, and myself first secured this species from beneath the bark of red gums that had been recently flooded by the overflow of the Yarra. Other specimens were found by me later under a piece of bark lying on the ground, and beneath stones.

Type in author's collection.

PSELAPHIDAE.

Articerus wilsoni, Lea.

(Trans. and Proc. Roy. Soc. S. Aust., xliii., 1919, p. 169.)

This species, which was named by Mr. A. M. Lea from specimens which I secured from nests of *Iridiomyrmex detectus*, at Eltham, near Melbourne, evidently is widely distributed, as a ♂ example was found by me last October in a nest of the same ant at Caboolture, some thirty miles north of Brisbane. Mr. Lea tells me that Mr. Elston has also lately obtained a specimen from a nest of *I. detectus* near Adelaide, so that probably wherever this ant is located specimens of the Pselaphid will be found also.

SCARABAEIDAE.

Panelus bidentata, n. sp.

Upper surface generally black, but with sides of prothorax towards apex, shoulders, and a spot on each elytron on outer edge near apex, red; basal 2 and apical 3 joints of antennæ darker than the intermediate ones; legs with femora and tibiae dark testaceous. Under surface with palpi and prosternum testaceous, the rest blackish.

Head large, depressed in front, somewhat convex behind, armed with two prominent prongs jutting out in front, space between prongs evenly rounded, punctures numerous and well defined, becoming slightly larger towards base. Prothorax about one and a-half times broader than long, moderately convex, sides sub-parallel to within about one-third of apex, then strongly narrowed; puncturation much as on head. Elytra at base slightly

1. Trans. Ent. Soc. N.S.W., vol. ii., pp. 150.

wider than prothorax, sides evenly rounded, rather strongly convex, with seven striae on each elytron, arranged singly; interstices flat, uniformly covered with a minute meshwork of fine lines; on the centre of each interstice at extreme base there is a minute nodule, but this would not be visible if the prothorax and elytra were closely applied. Scutellum minute, rounded behind. Under surface with metasternum moderately punctured, abdominal segments with a transverse row of minute punctures at their extreme base, but apical segment with a few extra punctures scattered about

Length.—3, breadth 2, mm.

Habitat—Victoria. Lakes Entrance (F. E. Wilson)

This interesting little Scarab was secured when sieving leaf debris collected in a thickly scrubbed gully near the landing stage at Kalimna, Lakes' Entrance.

I have not seen a specimen of *P. pygmaeus*, Macl., but my friend, Mr A. M. Lea, to whom I showed this specimen, tells me that in *pygmaeus* the elytral striae are arranged in geminate series, and that the prothoracic punctures are less coarse. *P. pygmaeus* also has no red markings

Type unique in author's collection

CHRYSOMELIDAE

Oomela bicolor, n.sp.

Flavous, nitid; apical five joints of antennæ, head, a large basal marking on prothorax, a transverse marking on each elytron, somewhat nearer base than apex; scutellum, tarsi, femora and base and apex of the four anterior tibiae, black or darker.

Head with a sharply defined, sparsely punctate depression midway between antennæ, another very shallow, ill defined one between eyes, and two others leading from upper ocular margins towards the infra antennal depression; antennæ with joint 1 thick, 2 shorter and somewhat oval, 3-6 elongate, subequal, 7-11 much thicker, 11 considerably longer than 10, and pale at apex Joints 1-6 sparsely clothed with pale pubescence, 7-11 more densely clothed with darker pubescence. Prothorax about three and a-half times as wide as long, moderately convex, basal and apical width subequal, front angles moderately rounded, hind angles more acute, sparsely and very minutely punctured. Elytra slightly wider than prothorax, sides evenly rounded, with regular

rows of punctures, becoming almost obsolete on apical declivity; interstices with a few minute punctures.

Length.—3 mm.

Habitat.—Queensland: Goodna (F. E. Wilson).

This species apparently comes closest to *O. variabilis*, Lea,[2] but differs from the description of that species in the sculpture of the head, shape of prothorax and markings. A pair of these rather handsome little Chrysomelids were secured from beneath the bark of a rotting log

Type in author's collection.

Chalcolampra parvula, n sp.

Broadly ovate, very convex; head, sides of prothorax, base of elytra and suture broadly, sides of elytra narrowly, reddish-brown, the rest black, and the whole nitid. First four joints of antennæ testaceous, the rest darker; legs flavous. Upper surface (with the exception of a few setae on front margin of clypeus) glabrous. Under surface brownish-red.

Head sparsely and rather indistinctly punctured, with a shallow depression just above each eye, clypeal suture broadly v-shaped, reaching back a little beyond the points of insertion of antennæ; about midway on each arm of the suture is a deep circular depression, between which and the eye the cephalic surface is somewhat raised; eyes very coarsely granulate; antennæ with joint 1 very stout, 2 thicker than 3, 3 nearly twice as long as 4. Prothorax strongly depressed, about three times as broad as long, sides narrowly margined and rounded, but slightly incurved towards middle, anterior angles a little produced, posterior rounded; with fairly large, though sparsely distributed, punctures, becoming less frequent at sides. Scutellum subtriangular, smooth, impunctuate. Elytra very convex, continuous with sides of prothorax, widest about midway, with nine rows of well defined punctures on each elytron, seventh and eighth row starting from a common puncture somewhat distant from the base of elytron, ninth row obsolete at about one-third; interstices with sparse smaller punctures.

Under surface with a depression on disc of metasternum, mesosternum and metasternum with sparse setigerous punctures, abdominal segments with scattered setigerous punctures and suf-

2 Trans Roy Soc, S Aust, vol. xl, pp 431.

face shragreened; elytral epipleurae rather wide, evenly decreasing from about midway between intermediate and hind coxae.

Length.—2.75 mm.

Habitat.—Victoria. Belgrave (F. E. Wilson).

Looked at from the side this little species is seen to have an outline forming a complete half circle. My unique specimen was obtained when sieving leaf debris, gathered at the foot of a treefern, growing in a very damp gully.

Type in author's collection.

[Proc Roy. Soc Victoria, 34 (N S), Pt I, 1921]

Art VI —*The Australian Species of Carex in the National Herbarium of Victoria*

By J R TOVEY

[Communicated by Professor A J Ewart, Ph D D Sc, &c]

[Read 12th May, 1921.]

In his Monograph of the Cyperaceae—Caricoideae in Engler's Pflanereich IV-20 (1909)—Kukenthal has changed the nomenclature of several of the Australian species of Carex and his systematic arrangement is quite different from that given in Mueller's Census of Australian Plants

As Engler's Pflanzereich is not readily available to many botanical workers, it was thought that the following notes giving the systematic arrangement according to Kukenthal, and also the distribution of the species in the National Herbarium, might be of some use to those interested in the above subject

It will be noted that several species which were included by Mueller and Bentham under well known European species have been considered by Kukenthal to be distinct, and some that have hitherto been recognised as valid have been reduced to varieties, whilst others that have been looked upon previously as synonyms have been raised to specific rank

Genus CAREX

Sub genus 1 **Primocarex**

C ACICULARIS Boott in Hook f Fl N Z 280 t 63 (1853)

Victoria It is also recorded from New South Wales and Tasmania but there are no specimens from either of these States in this Herbarium

C RARA Boott in Proc Linn Soc i 284 (1845)

Subspecies C CAPILLACEA, Boott Illustr Caric i, 44 t 110 (1858)

New South Wales

C PYRENAICA, Wahlenb in Vet Akad Handl, Stockholm, xxiv, p 139 (1803)

Var CEPHALOTES, Kukenthal in Engl Pflanzer, iv 20, p. 106 (1909), (C CEPHALOTES, F v M)

Victoria, New South Wales

Sub genus 2 **Vignea**

C CHLORANTHA R Br Prodr 242 (1810)
Victoria, New South Wales, Tasmania

C DECLINATA Boott Illustr Caric iv, 171 t 58 (1867)
New South Wales, Queensland

C TERETICAULIS, F v M Fragm viii, 256 (1874)
Victoria, South Australia, West Australia, Tasmania

C APPRESSA, R Br Prodr, 242 (1810) (*C paniculata F v M* non L)

Victoria New South Wales, Queensland, South Australia, West Australia, Tasmania

Forma 1 DIAPHANA Kukenthal (*C paniculata* var *subdiaphana*)

Queensland and South Australia

Forma 2 MINOR Kukenthal (*C chlorantha,* var *composita, Benth*)

Victoria, New South Wales, Tasmania

Var VIRGATA Kukenth, in Engl Pflanzr, iv 20, p 179 (1909)

New South Wales Tasmania

C INVERSA, R Br Prodr, 242 (1810)

Victoria, New South Wales, Queensland, South Australia, Tasmania

Forma 1 PARVULA Kukenth

New South Wales

Forma 2 MAJOR Boott

Victoria, West Australia

Var LEICHHARDTII Boeck

New South Wales, Queensland

C HYPANDRA, F v M Fragm, viii, 259 (1874)

Victoria, New South Wales

C. CANESCENS, L. Spec. Plant. i. 274 (1753).

Var. ROBUSTIOR, Blytt. ex Anderss. Cypr. Scand. 57 (1849).

Victoria; New South Wales.

C. STELLULATA, Good, in Trans. Linn. Soc., II., 144 (1794) (*C. echinata,* Boeck non Murr.)

Victoria; New South Wales.

Sub-genus 3. **Indocarex.**

C. INDICA, L. Mant. II, 574 (1771) var. FISSILIS, Kukenth. (*C. fissilis,* Boott.).

Queensland.

Sub-genus 4. **Eucarex.**

C GAUDICHAUDIANA, Kunth. Enum. II., 417 (1837) (*C. vulgaris,* Fries. var. *Gaudichaudiana,* Boott.) (*C. caespitosa,* F.v.M. non L.)

Victoria; New South Wales; Queensland; South Australia; Tasmania.

Var. HUMILIOR, Kukenthal in Engl. Pflanzr. iv.-20 p. 313 (1909).

Tasmania. Kukenthal records this variety from New South Wales, but there are no specimens from that State in this Herbarium

Var. CONTRACTA, Kukenthal in Engl. Pflanzr. iv.-20, p. 313 (1909).

(Syn. *C. contracta,* F.v.M.)

New South Wales.

C. POLYANTHA, F.v.M in Trans. Phil. Soc. Vict. i., 110 (1855). (*C. acuta,* F.v.M. non L.)

Victoria; New South Wales.

C. CERNUA, Boott. Illustr. Caric. iv., 171, t. 578 (1867).

Var. LOBELIPES, Kukenthal in Engl. Pflanzr. iv.-20, p. 354 (1909) (*C. lobelipes,* F.v.M.)

New South Wales.

C. BUXBAUMII, Wahlenb. in Vet. Akad. Handl, Stockholm, xxiv. 163 (1803).

Victoria. This is also recorded from New South Wales, but there are no specimens from that State in this Herbarium.

C. MACULATA, Boott in Trans. Linn. Soc., xx., p. 128 (1846).

Var. NEUROCHLAMYS, Kukenth in Engl. Pflanzr. iv.-20, p. 428 (1909) (*C. neurochlamys*, F.v.M.).

New South Wales; Queensland.

C. BREVICULMIS, R.Br. Prodr., 242 (1810).

Victoria; New South Wales; South Australia; Tasmania.

C. BRUNNEA, Thunb. Fl. Jap., 38 (1784) (*C. gracilis*, R.Br.).

New South Wales; Queensland.

C. LACISTOMA, R.Br., Prodr., 243 (1810).

Kukenthal records this species from New South Wales, but it is not represented in this Herbarium.

C. BROWNII, Tuckerm. Enum. Meth. 21 (1843).

Victoria, New South Wales.

C. ALSOPHILA, F.v.M. Fragm. viii., 257 (1874).

Victoria.

C. LONGIFOLIA, R.Br. Prodr., 242 (1810) (*C. longibrachiata*, Boeck).

Victoria; New South Wales; Queensland; Tasmania.

C. GUNNIANA, Boott in Trans. Linn. Soc. xx. 143 (1846).

Victoria; New South Wales, South Australia; and Tasmania.

Var. BARBATA, Kukenth. in Engl. Pflanzr. iv.-20 p. 663 (1909) (*C. barbata*, Boott.).

Kukenthal records this variety from Tasmania, but it is not represented in this Herbarium.

Var. BREVIOR, Kukenth. in Engler's Pflanzr. iv.-20 p. 663 (1909).

This variety is recorded from Gippsland, Victoria, by Kukenthal, but it is not represented in this Herbarium.

C. OEDERI, Retz. Fl. Scand. Prodr. 179 (1779). Var. CATARACTAE, Kukenth. in Engl. Pflanzr. iv.-20, p. 675 (1909), (*C. cataractae,* R.Br.), (*C. flava,* Benth., non L.)

Tasmania.

C. TASMANICA, Kukenth. in Bull. Herb. Boiss, 2nd Ser. iv., 59 (1904).

Tasmania.

C. PREISSII, Nees in Lehm. Pl. Preiss ii. 94 (1846).

West Australia.

C. PSEUDO-CYPERUS, L. Spec. Pl. ed. i. 97 (1753) var. FASCICULARIS, Boott. (*C. fascicularis,* Soland).

Victoria; New South Wales; Queensland; South Australia; West Australia; Tasmania.

C. PUMILA, Thunb. Fl. Jap. 39 (1784).

Victoria; New South Wales; South Australia; Tasmania. It is also recorded from Queensland, but there are no specimens from that State in this Herbarium.

Var. BICHENOVIANA, Kukenth. in Engl. Pflanzr. iv.-20, p. 740 (1909) (*C. Bichenoviana,* Boott.) (*C. haematostoma,* Boeck. non Nees).

Victoria; New South Wales.

This variety is also recorded by Kukenthal from South Australia and Tasmania, but it is not represented from either of these States in this Herbarium.

C. RICHMONDII (Boott. M.S.). Clarke in New Genera and Species of Cyperaceae in Kew Bull. Ad. Ser. 8, p. 83 (1908).

This is recorded from Tasmania, but Kukenthal does not record this species in his Monograph, and there are no specimens of it in this Herbarium.

Systematic arrangement according to Mueller		Systematic arrangement according to Kukenthal (The numbers show the order of sequence)
C cephalotes, F v M	=	(3) C pyrenaica, Wahl var cephalotes, Kukenth
C acicularis, Boott	=	(1) C acicularis, Boott
C capillacca, Boott	=	(2) C rara, Boott (subspecies C capillacea, Boott)
C inversa, R Br	=	(8) C inversa, R Br
C canescens, L	=	(10) C canescens, L
C echinata (Murr) Boech non Murr	=	(11) C stellulata, Good
C hypandra, F v M	=	(9) C hypandra, F v M
C chlorantha, R Br	=	(4) C chlorantha, R Br
C paniculata (L) F v M non Linn	=	(7) C appressa, R Br
C declinata, Boott	=	(5) C declinata, Boott
C tereticaulis, F v M	=	(6) C tereticaulis, F v M
C haematostoma (Nees), Boech non Nees	=	(29a) C pumila, var Bichenoviana, Boott
C fissilis, Boott	=	(12) C indica, L var fissilis, Kukenth
C brunnea, Thunb	=	(19) C brunnea, Thunb
C contracta, F v M	=	(13a) C Gaudichaudiana, Kunth var contracta, Kukenth
C caespitosa (L), F v M non Linn	=	(13) C Gaudichaudiana, Kunth
C acuta (L), F v M non Linn	=	(14) C polyantha, F v M
C lobolepis, F v M	=	(15) C cernua, Boott var lobolepis, Kukenth
C flava (L), Benth non Linn	=	(25) C Oederi, Boott var, cataractae, Kukenth (26) C tasmanica, Kukenth
C Buxbaumii, Wahl	=	(16) C Buxbaumii, Wahl
C pumila, Thunb	=	(29) C pumila, Thunb
C breviculmis, R Br	=	(18) C breviculmis, R Br

Systematic arrangement according to Mueller		Systematic arrangement according to Kukenthal The numbers show the order of sequence
C Neesiana, Endl. This is from Norfolk Island only, hence not Australian.		
C Preissii, Nees.	=(27)	C. Preissii, Nees.
C. Gunniana, Boott.	=(24)	C. Gunniana, Boott.
C Bichenoviana, Boott.	=(29a)	C. pumila, var. Bichenoviana, Boott.
C. maculata, Boott.	=(17)	C. maculata, Boott., var. neurochlamys, Kukenth.
C. lacistoma, R Br. (partim)	=(20)	C lacistoma, R.Br.
C. lacistoma, R Br. (partim)	=(21)	C Brownii, Tuckerm.
C. alsophila, F v.M.	=(22)	C. alsophila, F.v.M
C. longibrachiata, Boech	=(23)	C. longifolia, R.Br.
C. pseudo-cyperus (L)	=(28)	C pseudo-cyperus, L. var. fascicularis, Boott.

[Proc. Roy. Soc. Victoria, 34 (N.S.), Pt. I., 1921].

Art. VII.—*An Intercomparison of Important Standard Yard Measures.*

By J. M. BALDWIN, M.A., D.Sc.

[Read 14th July, 1921.]

In the year 1843 a committee[1] was appointed to superintend the re-establishment of the standards of length and of weight with a view of replacing the standards destroyed by fire in 1834. Forty similar bronze bars were cast in 1845, each bar 38 inches long, and one inch square in cross section. Near each end a cylindrical hole half an inch in diameter, and half an inch deep was sunk, the distance between the centres being 36 inches. At the bottom of each hole is a gold plug about 0.1 inch in diameter with three fine lines at intervals of about 0.01 inch transverse to the axis, and two lines about 0.03 inch apart parallel to the axis. The distance to be measured is that between the middle transverse lines measured from mid-way between the longitudinal lines.

One of these bars was taken as a reference standard, and each of the others was compared with this. At the close of the comparisons the bars were numbered, and the temperature at which each was standard was engraved on the top surface, which bore the following inscription:—

> "Copper 16 oz. tin 2½ zinc 1 Mr. Baily's Metal No. . . . Standard Yard at . . . . Fahrenheit. Cast in 1845. Troughtons & Simms, London."

Bar No. 1, Standard Yard at 62.00°F. was chosen as the Imperial Standard for determining the length of the Imperial Standard Yard,[2] and four others as Parliamentary copies. The reference yard was preserved to serve as a standard for reference, while the remaining bars were distributed throughout the world. One bar—No. 40, Standard Yard at 61.99°F.—is in the possession of the Melbourne Observatory. It differs from the others in that on the top surface "Experimental Bar A" is engraved instead of "Cast in 1845." No special reference is

1. G. B. Airy, Account of the Construction of the New National Standard of Length, Phil. Trans., Vol 147. Part III, 621—702, 1857.
2. Weights and Measures Act, 1878, First Schedule.

made to this in the Committee's report; presumably it was cast shortly before the other bars. This bar is in good preservation and the lines on the plugs are very good.

There is also at the Melbourne Observatory a second standard yard of similar metal and of the same length and cross section. The cylindrical holes are ½-inch in diameter, and only 0.1 inch deep, with gold plugs as before, but the lines parallel to the axis are ⅛-inch apart. The lines are not good, the central one on one plug being distinctly curved, and on the other not of uniform width. This bar was constructed in 1864, and is marked as standard at 57° Faht. The certificate issued by the Exchequer is dated 4th June, 1866. The bar will be referred to as (1383).

The expansion of 36 inches of the bronze used is given by Airy as 0.000341 ins. per degree Fahr. (l.c., p. 681), so that, assuming the permanence of the bars, the original comparisons would give (40)—(1383) = —.00170 inches when the bars are the same temperature. In August, 1915, these two bars were compared, and preliminary measures showed that (40)—(1383) = +.002 inches. At this time the history of (40) was unknown to me, but the workmanship gave evidence that it had been prepared with much greater care than (1383). The temperature at which the bars were standard was given in the one case as 61.99° F, in the other as 57° F. This pointed to the work of comparison of (40) having been more accurately carried out. The difference between the original and the later comparisons was so marked that it was impossible from the evidence before me to have any certainty of what the standard yard really was, and it was impossible at that time to send one of the bars to England to be re-investigated. In this difficulty, inquiries were made of the Deputy Warden of the Standards as to the history of bar (40), but before the receipt of his reply, it was identified by means of the paper cited above as being one of the original forty standard yard bars, and it was found that similar standards had been sent to Sydney and to Hobart. Further enquiries showed that these standards were still in existence, and thus a way was opened for an accurate determination of the yard by means of an intercomparison of these three original bars, each a replica of the British Imperial Standard Yard bar. After considerable delay, I was authorised by the Victorian Government to arrange for this intercomparison, and through the courtesy of the Minister for Lands of New South Wales, and

the Treasurer of Tasmania, the bars were brought to Melbourne, and the inter-comparison was carried out by me at the Melbourne Observatory during the months, June-November, 1918.

The New South Wales bar, No. 18, Standard at 62.26° F., was found when examined at the Melbourne Observatory to be in good condition, a few spots only appearing on the main portion of the bar, and the lines on the gold pins were very good. The Tasmanian bar, No. 37, Standard at 62.07° F., appeared in good condition as regards the outer surface, but on examining the lines under the microscope, those on the left hand plug were found to be fearfully scraped and utterly ruined; the only part for pointing on is at one end of the terminal line, outside the longitudinal lines. In the comparisons, pointings on the other terminal line were made at about the same distance outside the longitudinal lines, but evidently the original comparison of the bar cannot be used.

In the meantime the comparator to be used had been improved and had been given its final form, the micrometer screws investigated, and revolution values determined. The two microscopes used were supported in heavy cast iron stands which rested on a massive slate slab on stone piers isolated from the floor, the whole forming a most stable system. The microscopes can be raised and lowered, and the optical axis made vertical by three adjusting screws and lock nuts. The illumination is most important. A small electric lamp was fixed to the microscope tube a little above the objective. The light from it passed through a hole in the tube on to a cover glass inclined at 45° to the vertical, and thus the light was thrown vertically through the objective on to the line on the bar. This arrangement gave a good illumination. It could be somewhat improved by interposing a lens between the lamp and the hole in the tube, thus enabling the lamp to be moved further away The lamp was switched on only while the pointing was being made.

Two girders were bolted across from pier to pier, and on these were supported the rails on which the heavy wooden moving table ran. Cast iron tables, planed on the upper surface, three ins. wide and 48 ins. long, were supported near the ends by strong screws, fixed firmly into iron castings screwed to the moving table. These screws served for raising and lowering the cast iron table through a range of three inches. There were two of these tables side by side separated by a space of one inch.

Each of the two standard yards being compared was supported by a system of eight rollers, connected in groups of four, equi-spaced as described on p. 629 of the Phil. Trans. Vol. 147, the interval being $38/\sqrt{63}$ inches. The main support of each system of four rollers was a casting resting on three screws, the points of the screws being fixed relative to the tables by a point slot and plane arrangement.

With the limited means at my disposal it was impossible to have a constant temperature bath, but provision against rapid change in temperature was made by enclosing the whole of the supporting tables and the standards in a box, of which the moving table formed the bottom, the sides and top being wooden frames with panels of zinc outwards, and thick strawboard inside. The top was in three sections, to leave space for the microscopes to pass through. Two thermometers were supported horizontally midway between the standard bars Throughout the whole comparisons the greatest care was exercised to eliminate the effect of any progressive change, and the bars were measured in every arrangement. Thus in comparing two bars, A and B, eight series were made.

North/South · A/B, A/ꓭ, ∀/ꓭ, ∀/B, B/∀, B/A, ꓭ/A, ꓭ/∀,
so that any constant difference in temperature caused by the presence of the observer, who always was to the north, should have no effect on the final result. A series consisted of eight sets, the pointings in a set being in the order a, b, c, d, d, c, b, a where a, b, are the terminal lines on one bar, c, d those on the other bar. In the sets the first pointing was made on each line in turn. A series occupied about half an hour, and during this time the temperature of the thermometers in the box rose about 0.3°C. At the close of a series, the bars were placed in position for the next series, and a minimum time of about two hours elapsed before the next series was started. It is hoped that with the precautions observed any difference in temperature is entirely eliminated from the final mean.

There were thus in all 64 comparisons between any pair of bars, and in each comparison eight pointings were made, arranged symmetrically so as to eliminate any linear progressive change. There is no need to give full details of the readings; it will suffice to state that in no case did the difference between the extreme readings in the 32 comparisons of a group of four series exceed .00020 inch, this including all sources of error

except that arising from a constant difference in temperature between the bars depending on which occupied the North position.

The final mean from the comparisons are expressed by the following equations of condition, the subscript numbers referring to the mean temperature of comparison, and the absolute term being in inches.

					Computed	O–C.
$(37)_{53\cdot4}$	–	$(40)_{53\cdot4}$	=	+ 00018	+ ·00019	-1×10^{-5}
$(18)_{49\cdot2}$	–	$(37)_{49\cdot2}$	=	– 00034	– ·00035	+ 1
$(37)_{46\cdot7}$	–	$(1383)_{46\cdot7}$	=	+ 00176	+ 00173	+ 3
$(18)_{53\cdot3}$	–	$(40)_{53\cdot3}$	=	·00016	– 00016	0
$(1383)_{56\cdot0}$	–	$(18)_{56\cdot0}$	=	– 00136	·00137	+ 1
$(1383)_{61\cdot2}$	–	$(40)_{61\cdot2}$	=	00152	–00153	+ 1

The bars are all of the same alloy, and so the coefficients of thermal expansion can be assumed equal, and the equations solved for the three unknowns: (18)—(40), (37)—(40), and (1383)—(40). Giving equal weight to each equation the solution is—

$$(18)=(40)-.00016 \text{ ins.}$$
$$(37)=(40)+.00019 \text{ ins.}$$
$$(1383)=(40)-.00153 \text{ ins.}$$

(37) is so badly injured that the original determination cannot be used for fixing its length, while for (1383) it is almost certain that some error has been made in the reductions of the original comparisons. Hence only (18) and (40) remain for establishing the yard. The original comparisons give the temperatures at which they are standard as 62.26°F. and 61.99°F. respectively, from which it follows—

Original comparison, (18)—(40) = —.00009 ins.
Present comparison, (18)—(40) = —.00016 ins.

so that a relative change of 00007 inches between the two standards is indicated. This is of the order of changes shown between the similar bars which serve as Parliamentary Copies (see Report by the Board of Trade (Weights and Measures), 1912, p. 11). To distribute this change, assume that (18) has diminished by half the amount, while (40) has increased by half the amount. This change of .000035 inch corresponds to a change in the standard temperature of 0.10°F.

The final results are given in the following table:—

Bar.	Standard at Original	Standard at Present.	Length at 62° F. Original in	Length at 62° F. Present in	Difference. P–O. in.
18	62 26° F	62 36 F	1 yd. – ·00009	1 yd – 00012	– ·00003
40	61·99	61 89	+ 0	+ 4	+ 4
37	62·07	61·82	– 2	+ 23	+ 25
1383	57	66 4	+ 171	– 150	– 321

The changes shown in bars (18) and (40) are quite probable The change in bar (37) can be explained by the fact that pointings in the present series had to be made on a small part near the end of one of the terminal lines, instead of midway between the two longitudinal lines The difference in bar (1383) is altogether too large to be explained by a change in the length of the bar. The most probable explanation is that in the original comparison a mistake was made in the sign of the correction—that the bar, instead of being too long, as shown on the certificate, was in reality too short. This would assume that the temperature of comparison was 61.7°F., a quite likely temperature.

[Proc. Roy. Soc. Victoria, 34 (N.S.), Pt. I., 1921.]

Art. VIII.—*The Petrology of the Ordovician Sediments of the Bendigo District*

By J. A. DUNN, B.Sc.
(Howitt Natural History Research Scholar, 1920).

[Read 14th July, 1921.]

1. Introduction.

The Ordovician sediments form practically the only rocks actually represented in Bendigo, and outcrop over almost the whole area except where occasionally covered by shallow alluvium. The structure of the series has been so thoroughly described by numerous geological workers in the past, particularly E. J. Dunn[1] and F. L. Stillwell,[2] that no description is here needed. One or two points may however be noted.

An exhaustive examination of the graptolites obtained from different parts of the field has shown that the Lancefield, Bendigo and Castlemaine zones of the Lower Ordovician are represented here, but there is, however, no lithological difference in the representatives of these three zones. There is every gradation between a typical sandstone and a typical slate, and these are the only representatives of the original sediments. The fresh slate has a dark to light bluish-grey colour, the sandstone a dark to light grey shade On weathering this is altered to a buff colour in both cases, the slates being generally darker than the sandstone, except where the latter have been almost entirely replaced by limonite. The limonite staining is derived from the decomposition by meteoric waters of the pyrite contained in the fresh rock, and replaces the clayey material, and constitutes the more important cement of the weathered rock. Where, however, the importance of the limonite as a cementing medium is small, the sandstone becomes a soft, porous, crumbly sandstone, and the slate a fine greasy fissile material.

1. "Report on the Bendigo Goldfield," Nos 1 and 2. E. J. Dunn, Geol Surv Vict. 1896
2. "Gold Deposition in the Bendigo Goldfield," Parts I., II., and III. F. L. Stillwell. Bull 4, 8 and 16 Adv Council Sc. and Industry

2. Composition of the Sediments.

Secondary silica has, in many cases, altered the character of the original sediments, but it is quite apparent that as a whole both the sandstones and slates were highly aluminous. The principal minerals identified microscopically are quartz, felspar, muscovite, and biotite (generally altered to chlorite). The accessories detected are tourmaline, zircon, rutile, ilmenite (often altering to leucoxene), magnetite, apatite and sphene. A small pale-bluish isotropic mineral with very high refractive index was detected in one section of sandstone—this is probably blue spinel. Secondary minerals present are quartz, pyrite, arsenopyrite, sphalerite, galena, chlorite and a carbonate probably ankerite. Sericite constitutes practically the whole of the ground-mass of the slates, leucoxene often appears secondary to ilmenite, whilst chlorite generally occurs after biotite. In a number of the slates, particularly those found on the "backs," black carbonaceous matter constitutes an integral part of the rock, and generally occurs in thin lamellae.

(a) Essential Minerals examined in thin sections.—The detrital quartz and felspars range to about .7 mm. as a maximum in the standstones and mica often occurs in long, thin ragged plates up to 1 mm. in length.

The quartz is rounded to sub-angular in habit generally, but often where secondary it becomes sharply angular. Only in very rare instances does it show crystal boundaries. Strain polarisation is rarely evident except in some of the secondary quartz. The characteristic serial arrangement of inclusions is often noticeable, and apatite, zircon and rutile are occasionally found as inclusions. Thin veins of quartz often traverse both sandstones and slates—these veins are in part the result of replacement, and in part of growth by force of crystallisation.

The felspar is in much less quantity than the quartz, and on the whole the individual grains are smaller. Occasionally the felspars are in very turbid grey patches, but generally they are rather fresh and represented by both orthoclase and plagioclase. The plagioclase ranges from andesine to oligoclase as shown by the angle of extinction, and is not so abundant as the orthoclase. The felspars are almost universally rounded in habit, but where they are probably secondary, they become quite angular, as in the case of quartz. The alteration of the felspars is as a rule to sericite, but occasionally it goes to calcite.

Both detrital and secondary mica occurs the former as long ragged cleaved fragments of muscovite up to 1 mm in length and as rounded and ragged plates Although for the most part quite clear and colourless it occasionally alters to a pale green chlorite The muscovite is often found bent and nipped between the quartz grains and this is characteristic of every section examined Biotite occurs in one or two of the sandstones but is practically all altered to a greenish and brownish chlorite

The secondary mica is generally represented by sericite occurring throughout the ground mass of all the rocks and making up practically the whole of the slates The sericite constitutes most of the original clayey matter of the ground mass of the sandstones and at times is the result of alteration of the felspars Some of the plates of muscovite may possibly be secondary

(b) Accessory Minerals—Tourmaline is the dominant accessory and was detected in every section of sandstone Both the blue and brown pleochroic varieties are represented in grains up to 2 mm diameter Generally it occurs as rounded detrital grains but occasionally it shows traces of crystal boundaries Only in one case was tourmaline found to occur in slate and in that instance it was included in secondary arsenopyrite

Zircon occurs in all of the sections never exceeding more than 25 mm diameter It is always clear and colourless and generally slightly rounded though still showing crystal boundaries It is not so abundant in the slates as in the sandstones

Rutile occurs in a number of the sections but rarely exceeds more than 1 mm diameter Generally the grains are somewhat rounded brown and violet pleochroic tints being common

Apatite is a rather constant accessory in many of the sections in grains up to 3 mm maximum Although sometimes rounded it always shows traces of crystal boundaries

The determination of sphene in some of the sections is doubtful owing to the difficulty of distinguishing it from zircon in small grains But one or two boat shaped crystals with oblique extinction appear rather definite

Ilmenite is quite a common accessory in all the rocks occurring as irregular grains generally altering to leucoxene Magnetite also occurs in irregular grains rarely in minute octahedra

Carbonaceous material occurs especially in the slates and is probably the result of the decay of some form of life in the sediments during their deposition

(c) Secondary Minerals.—Quartz is the chief secondary mineral. Practically all the Bendigo rocks are silicified to a greater or less extent. This secondary silica occurs either in the ground-mass, or at times it forms small angular grains of quartz which have grown from definite points by force of crystallisation; this often gives the appearance of a sandstone to what was originally a slate. At other times the quartz acts as a border to secondary cubes of pyrite, generally bordering the quartz only in the direction of the cleavage of the slates.

Chlorite is an important secondary mineral. In part this appears to have been brought in with the secondary siliceous solutions, but occasionally it is secondary to muscovite, biotite and tourmaline.

Mineral carbonates, probably ankerite, are common as secondary minerals, generally replacing the ground-mass of both slates and sandstones, and occasionally replacing grains of felspar. These carbonates also appear to have accompanied the secondary siliceous solutions.

Pyrite, pyrrhotite, arsenopyrite, sphalerite, and galena occur distributed throughout the whole series. They occur both irregularly, and with definite crystal boundaries, and are probably contemporaneous with the siliceous solutions.

Leucoxene is secondary after ilmenite. The greater part of the sericite is also secondary, particularly in the slates and ground-mass of the sandstones—it is evidently the alteration product of the clayey material of the original sediments.

Heavy Liquid Separation of Minerals.

By means of heavy liquids, the minerals occurring in small quantity in a sample of sandstone were isolated and examined as grains under the microscope. A typical sandstone from the 2400 feet level of the Sea Mine was crushed, then ground in a disc crusher, and passed first through an 80-mesh sieve, then part through a 100-mesh, thus giving two grades of fineness. These were then weighed:—

2817 grams through 100-mesh.
438 grams through 80 mesh, and over 100-mesh.
3255 grams total.

These grades were each panned off separately to ensure cleaner panning. Residues were panned three times to have a minimum

loss of heavier minerals. By this means all slimes were got rid of, as well as a large proportion of the quartz. Concentrates dried, then passed under electro-magnet to separate any magnetic minerals. The magnetic minerals on examination consisted entirely of magnetite. This was also weighed:—

.9130 grams magnetite through 100-mesh.
.2889 grams magnetite through 80-mesh and over 100.

1.2019 grams magnetite total.

Magnetite in sandstone: .0307 per cent.

The demagnetised samples were each separated into a lighter and heavier portion, by means of flotation in bromoform S.G. 2.90, on the lines indicated by T. Crook, A.R.C Sc. (Dublin), F.G S., in "The Petrology of the Sedimentary Rocks," Hatch and Rastall. The concentrates obtained, i.e., the heavier portions, were weighed—

8.301 grams through 100-mesh.
3.756 grams between 80 and 100-mesh.

12.057 grams total concentrate.

These concentrates were seen to be heavily charged with sulphides, as pyrite and arsenopyrite. They were therefore first roasted to oxide, then again passed under electromagnet to eliminate pyritic matter, but a good deal of Fe_2O_3 still remained. Hence the only recourse left was to take it into solution with weak Hydrochloric acid, the leached residues being then filtered, dried and weighed—

2.7368 grams through 100-mesh.
0.4520 grams between 80 and 100-mesh.

3.1888 grams total.

Substracting this from the above 12.057 grams we find there was a total of 8 868 grams of sulphides in the sandstone, mainly pyrite.

Sulphide in sandstone—.2730 per cent.

The acid solution was tested for phosphate, as apatite appeared to be the only likely soluble mineral present. Presence of phosphate confirmed.

The filtered residues were noted to contain quite a large amount of quartz, hence a further heavy solution separation was under-

taken. Bromoform being now unobtainable, methylene iodide, diluted to S.G. 3.133 was used for the purpose. This would also eliminate the large amount of muscovite which the rock sections had shown to be present. The final concentrates obtained were weighed:—

0658 grams heavy minerals through 100-mesh.
.0091 grams heavy minerals between 80 and 100-mesh.

0749 grams heavy minerals total.

Heavy minerals in sandstone—.0023 per cent.

The heavy minerals were then examined under the microscope in media of different refractive indices, the following minerals being detected: Zircon, tourmaline, ilmenite, rutile, topaz, sphene, magnetite, spinel, apatite, biotite, corundum, pyrrhotite, arsenopyrite, chalcopyrite, pyrite, gold; some quartz, chlorite, and muscovite, probably brought down with other minerals during flotation; and perhaps monazite.

Zircon is, with tourmaline, the most abundant. The crystals almost always show perfect prismatic and pyramidal faces, and in many cases are zoned.

Tourmaline occurs abundantly as both the brown and bluish varieties, generally in irregular grains, although a crystal face can be occasionally detected.

Ilmenite is generally altered to white leucoxene, showing in many cases a black, unaltered core.

Rutile occurs in well-formed prisms, sometimes dark brown in colour, sometimes violet tinted.

Topaz occurs generally in irregular grains, but occasionally shows prismatic outlines. The colours vary from colourless, through straw yellow to light greenish yellow.

Sphene is present in angular and rounded brown grains, generally not so clear as zircon and rutile. The determination is rather doubtful.

Pleonaste, an almost opaque form of spinel, was represented by two or three octahedra. Practically black, but greenish tint detected on edges.

Apatite showing rounded boundaries, owing to the leaching in HCl occurs in colorless and pale-bluish grains.

Corundum, or sapphire, occurs, but only three irregular grains noted, deep blue in colour, and rather pleochroic.

One or two round grains with very high refractive index and birefringence were noted, possessing a strong honey-yellow colour, are probably monazite, although the distinction from rutile is doubtful.

Pyrrhotite, arsenopyrite, chalcopyrite, pyrite and gold were detected. The first four were evidently unacted on by the acid for some reason. The gold occurs in two or three irregular grains, and is quite evidently not detrital. Even after the grinding which the gold would have received during crushing, it appears quite crystalline, while one grain is thin and skeleton-like, as if it had occurred in a mineral which had been dissolved by acid. This inclines the writer to the view that the gold was included in pyrite, and on solution of this latter, was left as the minute grains noted—the largest is not greater than .2 mm. diameter. It is a well-known fact that throughout Bendigo pyrite carries gold often in considerable quantities. It may be here noted that this gold could not have been included during crushing, sieving or panning, as the disc crusher was first thoroughly cleaned with pure silica, the sieves and pans also thoroughly cleaned. The writer is convinced the gold was inherent in the sample.

Magnetite was detected in minute grains, evidently having escaped separation by the electro-magnet by reason of its small size.

Ragged plates of deep brown biotite, colourless muscovite, and greenish chlorite were detected, and were probably brought down by some of the heavy minerals during flotation.

3. Structural Alterations and Metamorphism.

The structural alterations of the Bendigo rocks are wholly dynamic—the development of cleavage in the more argillaceous sediments with the production of slates. No shales or mudstones are represented, all having been converted into slates. As these become more arenaceous, however, the cleavage is less developed, until in the true sandstone there is no evidence of it whatever. These structural changes are certainly a result of the same intense forces that brought into existence the peculiar regular and acute folding so typical of the area. Although the Ordovician is intruded by numerous monchiquite dykes (generally in the neighbourhood of the anticlinal axes), there has been no alteration of the walls of country rock. This is prob-

ably accounted for by the almost instantaneous intrusion of the molten material, the magmatic heat being quickly conducted away from the walls.

Some eight miles south of Bendigo, at Big Hill, the Ordovician, at the contact with the Harcourt granitic mass, has been somewhat metamorphosed.[3] Typically the sandstones have been altered to a mica hornfels, and the argillaceous sediments to spotted and andalusite slates. For the most part, however, the alteration is rather an induration than an absolute change in the mineral content of the rocks.

4. Deposition of the Sediments.

By numerous writers in the past, some of the Ordovician beds of the Bendigo goldfields have been referred to as deposited in shallow water, owing to the common occurrence of ripple-marking.[4] It was first thought by Dr. Hall, and later confirmed by T. S. Hart[5] that the origin of these pseudo ripple markings is due to the intense compressive forces to which the rocks have been subjected. It appears probable that during the process of folding, the resultant stresses along the bedding planes caused movement of the beds over each other, with the concomitant production of minute puckers in the more plastic beds. This may be the explanation of the more common occurrence of this pseudo ripple-marking in the slates than in the sandstones of Bendigo. Hence, this evidence of apparent ripple-marking cannot be accepted as a criterion of the shallow-water deposition of the sediments.

The general fineness in grain of the rocks rather points to the deposition of the sediments some distance from the shore, probably in the relatively deep-water of a continental shelf. The often rapid succession of exceedingly minute bands of slate and sandstone, with the admixture of occasional quite coarse sandstones, suggests that the sediments were laid down under variable currents, probably a result of tremendous floods washing the material from various sources.

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3 "Report on the Bendigo Goldfield," No. 1. E. J. Dunn, page 7.

4 "Report on the Bendigo Goldfield," No 1 E J Dunn, page 6.

5 "On some Features of the Ordovician Rocks at Daylesford, with a Comparison with Similar Occurrences elsewhere" T S Hart, M A, B.C E, Proc Roy Soc. Vic., 1901, page 176.

5. Origin of the Mineral Contents.

W. G. Langford,[6] in his discussion of the constitution and origin of the Melbourne Silurian Sediments, pointed out that there were two possible sources of the material for the silurian sediments. So also there are two possible sources of the Ordovician sediments:—

(a) They may have been derived from a pre-Ordovician igneous rock.

(b) They may have been derived from a pre-Ordovician sedimentary rock.

The presence of such minerals as muscovite, tourmaline, zircon, rutile, ilmenite, magnetite, apatite, topaz, and sphene would perhaps point to an igneous rock as the origin of the sediments, but being stable minerals they may easily undergo transportation from the sediments of one period to a later.

Biotite is very rare, and is generally altered to chlorite, but its presence would indicate either an igneous or a metamorphic origin, as would also the fresh felspars which are occasionally met with. In the sandstones, felspar grains are very few in number compared with the quartz, and are sometimes represented by turbid patches. The slates and the fine sericitic ground-mass of the sandstones, however, are purely argillaceous, and must have originally been of the nature of clay, which in its turn, must have come into being through the prolonged breakdown of felspars. The extreme fineness of this clayey material would rather point to an older sediment as the derivation of the greater part of it. The clear unaltered felspars, though few in number, would tend to show that at least part of the constituent mineral content was derived from an old igneous or metamorphic rock.

The gradual transition from Heathcotian to Lower Ordovician throughout Victoria eliminates the possibility of the Heathcotian being the source of the material, whilst any possible Pre-Cambrian outcrops are quite unknown anywhere within 100 miles of Bendigo.

The writer pictures, then, in the Lower Ordovician period, a gradually sinking landmass, probably to the east, over which outcropped Pre-Cambrian metamorphic sediments, intruded perhaps by occasional igneous masses. The denudation of this land

6 "The Petrology of the Silurian Sediments near Melbourne." W. G. Langford, B.Sc., Proc. Roy. Soc. Vic., Vol. XXIX, n.s., Part I, 1916.

mass provided the material for the Ordovician sediment. These in many cases had to be transported over long distances, so that felspars would be rarely preserved—only those derived from close at hand would remain as clear grains.

This work was undertaken at the suggestion of Professor E. W. Skeats, in order to attempt an examination of the Ordovician sediments as W. G. Langford[7] had done of the Silurian. In order to bring the two works on to a comparative descriptive basis, the writer has set his work out on as similar lines to those of Langford as space would allow.

Mineralogically, W. G. Langford's inference that the Ordovician and Silurian would contain somewhat similar constituents[8] is borne out, but it may be noted that the occurrence of strain polarisation in the quartz grains is not by any means common as Langford inferred may be the case. It is perhaps possible that the Melbourne Silurian sediments have been derived from an area where the Ordovician has been subjected to even still greater compressive forces than in the Bendigo area. Mineralogically, the only difference between the constituents of the two series appears to be the relative absence of sapphire and unaltered biotite in the Ordovician.

In conclusion the writer wishes to acknowledge his thanks to the Bendigo School of Mines' officials for the use of their assay laboratory; to Dr. F. L. Stillwell for the invaluable use of his rock sections; and to Professor E. W. Skeats and Dr. H. S. Summers for their occasional excellent advice.

7 Op. cit.
8. Op. cit., page 19.

[Proc. Roy. Soc. Victoria 34 (N.S.), Pt. I., 1921.]

Art. IX.—*On an Inclusion of Ordovician Sandstone in the Granite of Big Hill.*

By J. A. DUNN, B.Sc,

(Howitt Natural History Research Scholar, 1920).

[Read 14th July, 1920]

1—Foreword.

Big Hill lies some eight miles S.W. of Bendigo, overlooking the wide expanse of undulating plain extending southwards to Harcourt, Castlemaine and Maldon. Big Hill is one of a series of ranges surrounding the saucer-shaped Harcourt granitic area, all being in the nature of residuals, owing their existence to the metamorphism and induration of the Lower Ordovician at the contact of the granitic intrusion. The original sediments near Big Hill have been altered in places to quartzite and mica hornfels, chiastolite often showing in the slates Well preserved specimens of the altered Ordovician are practically unobtainable, the rocks having been weathered and leached to a considerable depth, in some places below 400 feet

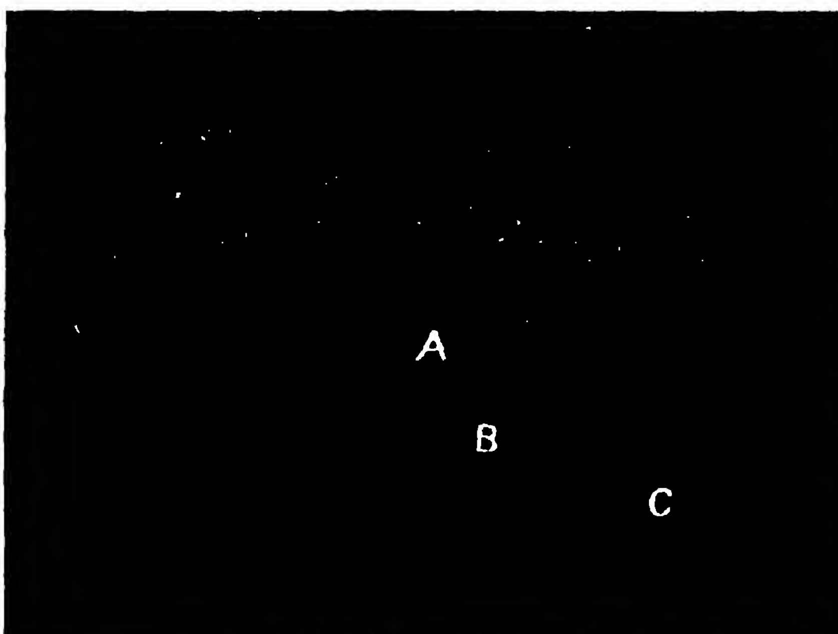
The exact line of contact between granitic intrusion and Ordovician is, at Big Hill, rather indeterminate owing to the accumulation of hill wash and alluvium on the hill slopes, and at the foot of the hills. However, in places large granitic boulders are found protruding above the surface, and by closely following the beds of the small creeks, the limits of the granitic mass may be very closely delineated.

2.—Ordovician.

The Ordovician of Big Hill forms the southern extension of the Bendigo Goldfields, and there are probably three horizons of the Lower Ordovician represented here—Lancefield, Bendigo and Castlemaine. The well-formed anticlines and synclines so typical of Bendigo extend south-west, right up to the Harcourt granitic mass at Big Hill, remaining undisturbed both in dip and strike at the contact. In fact, the Big Hill range may be looked upon as the southern limit of the Bendigo Goldfields, for the slopes of the range have been costeened and

scratched for gold in the past, although in rather a spasmodic manner.

The sediments are represented by sandstones and slates of varying composition and texture, there being every gradation between the normal sandstone and normal slate In Bendigo these have been mineralised to some considerable extent by the impregnation of quite a high percentage of pyrite, with lesser amounts of arsenopyrite, galena and sphalerite At Big Hill these sulphides are practically absent, but the Ordovician has been metamorphosed fairly extensively with the formation of micaceous sandstone (in some places the mica is in quite coarse plates), whilst the occurrence of chiastolite in the slates is common throughout the metamorphic aureole.



Inclusion of Country Rock (A), surrounded by Basic Segregation (B), in Granite (C).

3.—The Harcourt Granite Intrusion.

The granitic mass of Harcourt has never been critically examined, but it has generally been looked upon as a granodiorite similar to that of Macedon, Dandenong, Mount Eliza and Mount Martha. The high percentage of SiO_2 and the possibility that

many of the twinned felspars may be anorthoclase, as will be indicated later, point to the probability of the rock being a soda-rich granite similar to that at Station Peak. In fact, it is remarkably like this latter, often containing large phenocrysts of felspars although perhaps not as large as the You Yangs specimens.

Numerous veins of aplite and tourmaline aplite traverse the granitic mass, and also run out into the Ordovician at the contact. It is, however, with the method of intrusion and the differentiation of the Harcourt plutonic magma that this paper is more directly concerned.

The accompanying photograph is of an inclusion of country rock in the granite near Big Hill. This specimen occurs on the south slope of Big Hill, in the bed of a small tributary to Bullock Creek, and is situated at least 200 yards from the contact of the intrusion with the Ordovician. At this point the tributary has exposed the bare surface of the granite over an area of a few square feet, and has rounded and smoothed the rock surface considerably As will be noted from the photograph, the inclusion (A) stands up in relief from the granite surface (C). Surrounding the inclusion, except for two inches on the right-hand side, is what appears to be a basic segregation (B) from the hand specimen, and this latter, in contrast to both Ordovican inclusion and surrounding granite has been eroded to a maximum depth of three inches below the granite surface. Two very thin, light-coloured veins or threads cut through both the country rock and segregation, and apparently run into the granite at the side where the granite is in actual contact with the sandstone inclusion. The original sandstone has been altered to a considerable extent.

Description of specimens:—

Granite. Big Hill.—A light grey apparently normal granite of quartz, felspar and biotite, often containing fairly large crystals of felspar Under the microscope shows typical granitic texture. Abundant quartz and orthoclase in large allotriomorphic crystals, twinned and zoned felspars ranging from oligoclase to albite in smaller crystals, but relatively abundant and approximately equalling orthoclase in amount. Owing to the extremely minute twinning of some of the felspars, they may be possibly anorthoclase. In two or three of the large orthoclase crystals extremely thin lamellae can be just barely detected, pointing to a possible

soda variety. Microperthitic intergrowth of albite in orthoclase is common. Brown biotite altering in places to chlorite is an essential constituent. Accessories are apatite (occasionally in large crystals), zircon, and rarely sphene.

A determination of the silica percentage gave a result closely approximating Daly's average of 69.92 for true granites—this result is given later. The silica percentage is rather high for a granodiorite, and it is thus very possible that some of the apparent plagioclase felspars may be anorthoclase.

Basic Segregation around Inclusion, Big Hill.—A dark-grey, fine to medium-grained holocrystalline rock, consisting in the hand-specimen of quartz, felspar, and abundant biotite. Both in texture and appearance, it is quite distinct from the surrounding granite.

Microscopically the rock is seen to be much finer in texture than the granite. There is a large increase in plagioclase, decrease in percentage of quartz, whilst orthoclase is not at all common. There is also a slight increase in biotite, whilst apatite, though still relatively abundant, never occurs other than as small crystals. Other accessories are zircon, sphene, and a little magnetite in biotite. Biotite altered in part to chlorite.

This rock is the equivalent of a typical granodiorite, the silica percentage (see later) approximating closely to Daly's average of 65.15 for granodiorites.

Inclusion of Altered Sandstone, Big Hill.—A fine-grained, light-buff coloured rock, containing a good deal of mica.

Microscopically the section shows a granular quartz mosaic, with occasional sub-angular grains of orthoclase and plagioclase. Abundant biotite, generally occupying interstices between quartz grains. Detrital zircon and apatite, whilst needles of apatite are often included in the quartz grains.

The rock is evidently a re-crystallized sandstone.

There are two possible modes of formation of the basic segregation open to discussion, explained by each of the two hypotheses of magmatic differentiation postulated by Daly and Bowen respectively.

4.—Mechanics of Intrusion.

(a) Accepting first Daly's hypothesis of magmatic stoping combined with marginal assimilation, we would picture the molten igneous mass intruding its way up through the Ordovician by

magmatic stoping, assimilating the country rock as it progresses. The particular inclusion at Big Hill would be looked upon as a fragment of Ordovician which had not been entirely digested, whilst the surrounding basic segregation would be explained as granite which in the immediate neighbourhood of the Ordovician had its composition altered by solution of the sedimentary rock. Under normal circumstances of slow diffusion, the alteration of composition of the granite would be a gradual and progressive one, from a maximum at the surface of the country rock outwards to the normal granite. The acute change of composition of this segregation at the margins would, however, be explained by picturing the fragment as being localised to a certain definite neighbourhood until a state of equilibrium was reached so far as slow diffusion was concerned For some short distance around the fragment of sandstone, the granite magma would now be of an approximately similar composition throughout. If now further movement of the magma took place, so that the position of the fragment were altered—as, for instance, if the sandstone commenced to sink—then this equilibrium would be immediately disturbed. A certain amount of the surrounding altered magma would be carried with the inclusion and corroded by the magma to some extent, until finally, the whole granitic intrusion crystallized out.

On this hypothesis of magmatic stoping and marginal assimilation it would, as a necessary corollary, be presupposed that the segregation immediately surrounding the fragment would be of a composition intermediate between that of the granite, and included country rock, i.e., an inclusion of higher SiO_2 content than the granite should give a surrounding segregation of more acid composition than the granite, while a more basic inclusion would give a segregation of less acid composition. The upholding of this supposition by chemical analysis would go a long way towards the acceptance of the hypothesis, whilst a negative result from chemical analysis would mean the absolute rejection of the hypothesis of marginal assimilation so far as this occurrence is concerned. The following are the average silica contents of the three rock types as shown by analyses kindly undertaken by Miss McInerny, of the Geology School, University of Melbourne:—

Country rock (sandstone)	78.30 per cent. SiO_2
Segregation	65.30 per cent. SiO_2
Granite	69.79 per cent. SiO_2

The segregation is thus not of an intermediate composition, the SiO_2 content being lower than either of the other two; hence the hypothesis of marginal assimilation as applied to the explanation of the origin of the segregation surrounding the Big Hill inclusion of country rock must be rejected.

(b) The theory of magmatic differentiation upheld by Bowen affords an excellent explanation of the origin of the basic "aureole" to the inclusion. This "aureole" would represent a portion of the chilled border facies attached to the roof, and subsequently broken off with some of the country rock, to be incorporated in the parent magma. At the intrusion of the molten magma, the cooling at the marginal walls would be ahead of the cooling of the main mass, and here there would probably crystallize out a rock of the same composition as the molten magma at that instant. The main mass of the magma would remain still liquid, and as cooling progressed differentiation by sinking of crystals would continue, the liquid magma becoming more and more acid until, ultimately, the whole would crystallize out, producing as an ideal result an acid alkalic magma with a less acid and more calcic border (the chilled border facies). But prior to the crystallization of the main liquid magma, picture a rejuvenation in the mechanical activity of the magma brought about perhaps by earth movement, so that magmatic stoping commenced afresh. Picture also a small roof pendant of country rock projecting into the magma, and around which a "chilled border facies" has crystallized. With the renewal of magmatic stoping this roof pendant and its attached basic granitic border will break away from the main country rock, and sink into the liquid magma to be perhaps slightly corroded, but finally isolated in the granite on solidification of the magma. This will also explain the curious shape of this particular inclusion of Big Hill—a fragment of country rock (about six inches wide and two feet long), surrounded by a basic segregation except on that side which may be pictured as the area of attachment to Ordovician roof.

This, then, is quite an acceptable explanation of the origin of this inclusion, and considered as such, the Big Hill inclusion affords excellent evidence of the possibilities of both Daly's hypothesis of magmatic stoping, and Bowen's research on the differentiation of rock magmas, particularly as applied to the origin of "chilled border facies."

By J. M. LEWIS, D.D.Sc., Melb.

[Art. XV, Proc Roy. Soc. Victoria, 33 (N.S.), 1921]

Owing to a number of errors having escaped correction by the author, the Council has agreed to its separate issue with alterations and certain additions. Those specially interested in the subject may obtain a copy on application to the author, Dental College, Melbourne.

END OF VOLUME XXXIV, PART I.

[Issued 31st October, 1921]

[Proc. Roy. Soc. Victoria, 34 (N.S.), Pt. II, 1922.]

Art. X.—*An Alphabetical List of Victorian Eucalypts.*

By J. H. MAIDEN, I.S.O., F.R.S., F.L.S.

(Government Botanist, and Director of the Botanic Gardens, Sydney.)

[Read 11th August, 1921.]

This is a supplement to a paper, "A Census of Victorian Eucalypts and Their Economics," *Rep. Aust. Assoc. Adv. Sci.*, XIV., 294 (1913), by R. T. Baker.

The letters C.R. and F.F. indicate my "Critical Revision of the Genus Eucalyptus" and "Forest Flora of New South Wales" respectively. In these works I have, as a rule, indicated the references to Victorian localities.

It seems to me that we have 62 species proved to be indigenous to Victoria.

1. E. ALPINA, Lindl.

See C.R., Part IX., p. 259, Plate 41 (1907).

2. E. BAUERIANA, Schauer. (Synonym *E. Fletcheri*, R. T. Baker).

See C.R., Part XIII., p. 120, Plate 59 (1911); also F.F., Part LVII., p. 149, Plate 215 (1916).

The Metung, Victoria, specimens were collected by A. W. Howitt, and also by myself, following his directions. In C.R., Part XLII., I have enumerated some other Victorian specimens; these are in the Melbourne Herbarium, and were included in *E. polyanthemos* by Mueller. I have lately received the species with smaller leaves, simulating in that respect *E. populifolia* to some extent, from Mr. Harry Hopkins, from Orbost and the Tambo River.

3. E. BEHRIANA, F. v. M.

See C.R., Part X., p. 335, Plate 48 (1909); also F.F., Part XLVI., p. 111, Plate 172 (1912).

4. E. BICOLOR, A. Cunn.

(Quoted by Mr. Baker as *E. pendula*, A. Cunn., at p. 298, and as *E. pendula*, F.v.M., at p. 302).

See C.R., Part XI., p. 6, Plate 49 (1910); also F.F., Part XLIV., p. 76, Plate 164 (1911).

There is no such species as *E. pendula*, F.v.M., so far as I am aware, but notes on *E. pendula*, Page, and *E. pendula*, A. Cunn., will be found at pp. 7 and 8 of Part XI. of my C.R. (1910). They are *nomina nuda* and synonyms of *E. bicolor*, A. Cunn.; see p. 6 of that Part, and Plate 49. For some Victorian localities of *E. bicolor*, see p. 10.

5. E. Blaxlandi, Maiden and Cambage.

See *E. capitellata*, at p. 83 below.

6. E. Bosistoana, F.v.M.

See C.R., Part XI., p. 1, with Plate 49 (1910); also F.F., Part XLIII., p. 58, Plate 160 (1911)

7. E. botryoides, Sm.

See C.R., Part XXIII., p. 51, Plates 98, 99 (1915).

8. E. calycogona, Turcz.

See C.R, Part III., p. 83, Plate 9 (1903)

9. E. cinerea, F.v.M.

(Synonyms *E. pulverulenta*, F.v.M., non Sims; *E. Stuartiana*, F.v.M., var. *cordata*, Baker and Smith.)

See C.R., XXI., p. 2, 7 (1914).

10. E. cladocalyx, F.v.M.

The fact that Mueller suppressed this (1852) name in favour of his own, later described, *E. corynocalyx* (1860) is historical. I have explained the facts in C R, Part XXXVI., p. 163 (1919), with the evidence as to the Victorian locality, and elsewhere, e.g., *Proc. Roy. Soc. S.A.*, xli., 341 (1917), and they appear to admit of no controversy.

11. E. Considentiana, Maiden.

See C.R., Part X., p. 312, Plate 46 (1908); F.F., Part XXXVI., p. 90, Plate 136 (1909).

12. E. CORIACEA, A. Cunn.

See C.R., Part V., p. 133, Plates 26-28 (1904); F.F., Part XV., p. 116, Plate 58 (1905).

13. E. CORYMBOSA, Sm.

This was recorded as a Victorian plant by Mueller in his "Eucalyptographia." See C.R., Part XXXIX., p. 246 (1919). See also F.F., Part XII., Plate 45 (1904).

14. E. DIVERSIFOLIA, Bonpl.

E. santalifolia, F.v.M., is a synonym of *E. diversifolia*, Bonpl. See C.R., Part XXXIII., p. 84 (1917), together with Part VII., p. 197, Plate 36 (1905).

15. E. DIVES, Schauer.

See C.R., Part VII., p. 190, Plate 35 (1905); F.F., Part XIX., p. 176, Plate 75 (1906).

16. E. DUMOSA, A. Cunn.

I agree with Mr. Baker that this had better stand as a species as distinct from *E. incrassata*. The matter is not free from difficulty, owing to the absence of the type of *E. incrassata*, and I have tried to make the position clear in C.R., Part XXXVIII., p. 223 (1919). For figures see Plate 19, Part IV. (1904). Victorian localities are quoted in both Parts. It is also figured at Plate 245, Part LXV. of F.F., now in the press

17. E ELAEOPHORA, F.v.M.

See C R., Part XIX, p. 275, Plates 82 and 83 (1913).

18. E. EUGENIOIDES, Sieb.

Dealt with in C.R., Part VIII., p. 232, Plates 39 and 40 (1907). See also F.F, Part XXIX., p. 153, Plate 110 (1908).

E. eugenioides, Sieb., var *nana*, Deane and Maiden, I have identified with *E. ligustrina*, DC; see C.R., Part XL., p. 332, with Plate 167. I only know it from New South Wales, at no great distance west and south of Sydney, but Mr. Baker quotes Mr. P. R H. St. John as having found it at Orbost, Victoria. Mr. St. John writes to me recently that he was under the impression that he had sent me one of his Orbost specimens at the

time, but he is under a misapprehension, although he wrote to me about it. I therefore hold *E. ligustrina,* DC., in suspense as a Victorian plant for the present.

19. E. FRUTICETORUM, F.v.M., Fragm. ii., 58 (1860-1).

This was subsequently redescribed by Mr. Baker under the name *E. polybractea* (Proc. Linn. Soc. N.S.W., XXV., 692, 1900). The history of the synonymy is given in C.R., Part XI., figs. 6-8, Plate 52 (1910), with a full plate of a specimen named by Mueller himself, in F.F., Part XLII., p. 27, Plate 156 (1911). See also a paper by me, "Is *Eucalyptus fruticetorum,* F.v.M., identical with *E. polybractea,* R. T. Baker?" in *Journ. Roy. Soc. Vict.,* XXVI., 298 (1913). Mr. Baker quotes them as separate species at pages 302 and 307 of his paper.

20. E. GIGANTEA, Hook. (Synonym, *E. delegatensis,* R. T. Baker).

The confusion that has gathered around this species is explained in C.R., Part XX, p 291, Plate 85 (1914). See also F.F., Part LI., p. 7, Plate 198 (1913), (with photographs).

21. E. GLOBULUS, Labill.

See C.R, Part XVIII, p. 249, Plate 79 (1913); also F.F., Part LXVII., Plate 253, now in the press.

22. E. GONIOCALYX, F.v.M.

See C.R., Part XIX., p. 267, Plate 81 (1913); F.F., Part V., p. 119, Plate 19 (1903).

23. E. GRACILIS, F.v.M.

See C R., Part XXXIX., p. 265 (1919), as to Victorian localities. See also Part III., p. 81, Plate 12 (1903), as a variety of *E. calycogona,* Turcz.

24. E. GUNNII, Hook. f.

See C.R, Part XXVI., p. 108, Plate 108 (1916).

25. E. HEMIPHLOIA, F.v.M.

See C R. Part XI, with plate 50 (1910) for discussion of the question as to whether *E. hemiphloia* has for varieties *albens*

and *microcarpa* or not. Both these varieties are common in Victoria, while the typical form does not appear to occur there. For a figure of the normal form, see F.F., Part VI., p. 134, Plate 22 (1904).

26. E. INCRASSATA, Labill.

As to whether typical *E. incrassata*, originally described from Western Australia, has been found in Victoria as distinct from the named varieties of this species, I am not prepared to say, in view of the uncertainty which has gathered around *E. incrassata*. The matter is discussed in my C.R., Part XXXVIII., pp. 220 and 223 (1919).

E. INCRASSATA, Labill., var. ANGUSTIFOLIA, Maiden.

I have described no such variety. It is probably a slip of Mr. Baker's pen for var. *angulosa*, Benth. See C.R., Part IV., p. 101, Plate 14 (1904), which occurs in Victoria, see p. 108.

27. E. KITSONIANA, Maiden.

See C.R., Part XXVIII., p. 165, with Plate 117 (1916).

28. E. LEUCOXYLON, F.v.M.

See C.R., Part XII., p. 88, Plate 56 (1910).

29. E. LONGIFOLIA, Otto et Link.

See C.R., Part XX., p. 295, Plate 86 (1914); F F., Part II., p. 37, Plate 5 (1903).

30. E. MACRORRHYNCHA, F.v.M.

See C.R., Part VIII., p. 225, Plate 39 (1907); F.F., Part XXVII., p. 120, Plate 102 (1907).

31. E. MACULATA, Hook.

This occurs in Gippsland, Victoria, and notes on the localities will be found in C.R., Part XLIII., Plate 178, now in the press See also F.F., Part VII., p. 164, Plate 27 (1904).

32. E. MACULOSA, R. T. Baker.

See C.R., Part XXVII., p. 127, with Plate 112 (1916).

33. E. MAIDENI, F.v.M.

See C.R., Part XVIII., p. 256, Plates 79 and 80 (1913).

34. E. MELLIODORA, A. Cunn.

See C.R., Part XIV., p. 135, Plate 61 (1912); F.F., Part IX., p. 197, Plate 35 (1904).

35. E. MITCHELLIANA, Cambage.

In *Journ. Roy. Soc. N.S.W.*, LII., 457 (1918), with a plate. Summit of Mt. Buffalo.

36. E. MUELLERIANA, Howitt.

See C.R., Part VIII., p. 219, with Plate 2, Part 1 (1903).

37. E. NEGLECTA, Maiden.

See C.R., Part XXVII., p 151, with Plate 115 (1916).

38. E NITENS, Maiden

See C.R., Part XIX., p. 272, Plate 81 (1913).

39. E NUMEROSA, Maiden.

For Victorian localities see C.R., Part XXXVIII., p. 233 (1919). For earlier views of the relations of this species, see Part VI., pp. 155, 161, with fig. 1, Plate 30 (1905), and F.F., Part XVII., p. 147, Plate 66 (1905).

40. E. OBLIQUA, L'Herit.

See C.R., Part II., p. 51, Plates 5 and 6 (1903); F.F., Part XXII., p. 20, Plate 83 (1907).

41. E. ODORATA, Behr.

See C.R., Part XI., p. 34, Plate 51 (1910), for some Victorian localities.

42. E. OLEOSA, F.v.M.

See C.R., Part XV., p. 171, Plates 65 and 66 (1912); modified by Part XXXIX., p. 277 (1919). See also F.F., Part LX., p. 271, Plate 226 (1917).

43. E. OVATA, Labill.

I have stated that this includes *E. paludosa*, R. T. Baker, in Part XXVII., p. 140, figs. 6a-6d, Plate 114 (1916). I have re-examined (1920) *E. paludosa* with additional material received

from Mr. Baker, which material more closely approximates to the type of *E. ovata* than any I had previously received from him. I have been unable to alter my carefully considered opinion of 1916. (1920).

Concerning *E. camphora,* R. T. Baker, in C.R., Part XXVII., p. 148, with Plate 115 (1916), I have suggested that this may be a variety (*camphora*) of *E. ovata,* Labill. I have (1920) again carefully gone over the *ovata-camphora* material, with the view of re-establishing *E. camphora* if I could do so. I find, however, that additional experience and specimens confirm the opinions I expressed at p. 149 (*loc. cit.*). I find long petioles in both *E. ovata* and *E. camphora,* and think I have fairly stated the position for and against species and variety. I know the tree well, not only having observed it carefully in my Victorian tour in 1900, but in New South Wales before and since. The "dwarf variety" of *Gunnii* of Howitt is stated by Mr. Baker to be his *E. camphora.* At p. 150 (*loc. cit.*) I have stated that Howitt's "dwarf variety (b)" is *E. Kitsoni,* Maiden, and that the "Dwarf Highland form (d)" is *E. neglecta,* Maiden. No other "dwarf variety" is mentioned by Howitt so far as I know, but the "tall mountain form (c)" is *E. camphora,* R. T. Baker, as stated by me.

44 E. Perriniana, F.v.M., non R T.B et H.G S.

I have stated the case in C.R., Part XXVI,. p. 103, with plate 108 (1916).

45. E. pilularis, Sm.

See C.R., Part I. p. 38, Plate 1 (1903); F F, Part XXXI., Plate 116 (1908).

Having re-examined the Victorian specimen that Mr. Baker quotes on my authority (C.R., I., 38) I withdraw it, believing it to be *E. Muelleriana,* Howitt. It is, however, not quite satisfactory. Professor Ewart informs me, on Mr St. John's authority, that the specimen attributed to that gentleman was taken from a tree growing in the Melbourne Botanic Gardens. But Professor Ewart also sends me, for examination, a specimen of *E. pilularis* collected at National Park, Sealer's Cove, Wilson's Promontory (J. W. Audas and P R. H. St. John, 22nd October, 1909), which, although incomplete, is in my view sufficient to validate record of the species as Victorian. Professor Ewart

also thinks that the McAlister River record, *Mueller* (B.Fl., iii., 208), is probably correct, although the specimen has disappeared from the Melbourne Herbarium. The most southern New South Wales record for *E. pilularis* known to me is Mogo, near Moruya, and it is hoped that specimens will be collected to connect this with the Victorian one.

46. E. POLYANTHEMOS, Schauer.

See C.R., Part XIII., p. 109, with Plate 58 (1911); also F.F., Part LIX., p. 250, Plate 223 (in both these works lanceolate leaves are not shown). In Part XLII., C.R., will be found additional Victorian localities for the species, including some specimens seen by Mueller.

47. E. RADIATA, Sieb.

See C.R., Part XXXVIII., p. 230 (1919) for Victorian localities. For an earlier view as to *E. radiata,* see Part VI. of the same work. See also F.F. (as *E. amygdalina*), Part XVII., Plate 62 (1905).

Concerning *E amygdalina,* Labill., and var. *australiana,* Baker and Smith, my latest views in regard to *E. amygdalina* and some of its allies will be found in C.R. Part XXXVIII., pp. 227, 229, 233. I agree with Messrs. Baker and Smith that the presence of the Tasmanian *E. amygdalina* has not yet been proved on the mainland. But both *E. radiata,* Sieber (*E. amygdalina,* var. *australiana*), and *E. numerosa,* Maiden, species formerly looked upon as synonyms of *E. amygdalina,* not only occur on the mainland, but are by no means rare in Victoria.

The *E. radiata,* Sieb., referred to by Mr. Baker at p.305 of his paper, is that tree (a "White Gum") confused with it by Bentham, Woolls, others and myself, but which I subsequently showed to be another species under the name of *E. numerosa* (see Journ. Roy. Soc. N.S.W., XXIX, 752, 1904).

48. E. REGNANS, F.v.M.

See C.R., Part VII., p. 183, Plate 33 (1905); F.F., Part XVIII., p. 165, Plate 71(1905).

49. E. ROSTRATA, Schlecht.

See C.R., Part XXXIII., p. 68, Plates 136-8 (1917); F.F., Part LXII., p. 49, Plate 223 (1918).

50 E RUBIDA, Deane and Maiden

See C R, Part XXVI, p 110, Plates 109-111 (1916). Also F F, Part LXIII, p 87, Plate 237 (1920) I concur in Mr Baker's view that this is *E viminalis* variety (b) of Howitt, but he has overlooked my same record in *Proc Linn Soc N S W*, XXVI, 578 (1901), 12 years earlier

51 E SIDEROXYLON, A Cunn

See C R, Part XII, p 82, Plate 55 (1910), F F, Part XIII, p 70, Plate 49 (1904)

52 E SIEBERIANA F v M

See C R, Part X, p 306 with Plate 45 (1908), also F F, Part XXXIV, p 49, Plate 128 (1909) As regards the confusion with *E virgata,* Sieb, see p 82 below

53 E SMITHII, R T Baker

See C R, XII, p 76, Plate 55 (1910) but without a Victorian locality

54 E STELLULATA, Sieb

See C R, Part V, p 127, Plate 25 (1904), F F, Part XIV, p 94, Plate 54 (1905)

55 E STUARTIANA, F v M

In C R, Part XXI, pp 4 and 6, I have explained that Mueller mixed up his *Stuartiana* very much, including no less than three distinct species under that name *E Bridgesiana,* R T Baker, is the third of these three, and I have pointed out (*op cit*, XXIV p 68) that the description of a species under another name does not remove the difficulties

E Stuartiana (*E Bridgesiana*) is described at Part XXIV, p 68, and Plates 101 and 102 (1915) Victorian localities at p 69

E Stuartiana, F v M, as understood by Mr Baker, is synonymous with *E cinerea,* F v M See my C R, Part XXI, pp 1 and 2, and Plate 89

As regards *E Stuartiana,* F v M, var *cordata,* Baker and Smith, see my C R, Part XXI, p 5 (1914), where I state that it is synonymous with *E cinerea,* F v M (var *multiflora,* Maiden) See Part XXI, p 7, Plates 89 and 90

56. E. TERETICORNIS, Sm.

See C.R., Part XXXI., p. 5, Plate 128 (1917).

57. E. TRANSCONTINENTALIS, Maiden.

As to Victorian localities, see C.R., Part XXXIX., p. 270 (1919) with the localities indicated at Part XV., p. 171.

58. E. UNCINATA, Turcz.

See C.R., Part XIV., p. 143, Plate 62 (1912).

59. E VIMINALIS, Labill.

See C.R., Part XXVIII., p 167, Plates 117-119 (1916).

E. VIMINALIS, var. PLURIFLORA, J.H M. (Maiden).

Although I cannot trace this reputed variety attributed to me at the moment of writing, attention may be invited to my note of another variety, viz., *racemosa*, F v.M., in *Proc. Roy. Soc. Tas.*, p. 90 (1918) The type appears to have come from Port Phillip, and I have given a number of Victorian localities in Part 64 of F.F.

60. E. VIRGATA, Sieb.

Synonymous with *E. Luehmanniana*, F v.M. For a history of the confusion of this shrub (or very small tree) with *E. Sieberiana*, F.v.M., see C.R., Part XXXIX., p. 283 (1919); with C.R., Part IX., figs. 1 and 2, Plate 43; also Plate 44 (as *E. Luehmanniana*).

61. E. VIRIDIS, R. T Baker.

This will be found figured and described as *E. acacioides*, A. Cunn., in C R., XI., 45, figs. 9-12, Plate 52 (1910), and in my F.F., Part XLVIII., Plate 180 (whole plate), but I have since satisfied myself that Cunningham's material is mixed.

62. E. VITREA, R. T. Baker.

See C.R., Part VI., pp. 150 and 164, and Part VII., p. 189, with Plate 34 (1905); F.F., Part XXIII., p. 39, with Plate 86 (1906). See also *Journ. Roy. Soc. N.S.W.*, LII., 516 (1918), in which I try to clear up its relations to *E. vitellina*, Naudin.

For notes on Victorian localities see a paper by myself in *Journ. Roy. Soc. N.S.W.*, LII., 517 (1918).

Excluded Species.

In some cases it may be almost confidently predicted that they will be found to occur in Victoria, but it is best, in a list like this, to admit none without absolute proof

E. AMYGDALINA, Labill.

See C R., Part XXXVIII., p. 227 (1919), where I agree with Messrs. Baker and Smith that the original species appears to be confined to Tasmania At the same time it should be looked for on the Victorian coast. For the *E. amygdalina* as understood by Bentham, Mueller, and other botanists, see C.R., Part VI.

E. CAPITELLATA, Sm.

For many years I concurred in the general opinion that this species, originally described from Port Jackson, extended to Victoria. See my C R., Part VIII., p. 211, with Plate 37, in part (1907). I am now of opinion, as expressed in Part XLV.,p 147, that it does not extend to Victoria,and that some of the Victorian specimens are referable to *E Blaxlandi*, Maiden and Cambage, *Journ. Roy. Soc. N.S.W.*, LII., 495 (1918).

E. DEALBATA, A. Cunn.

See C.R., Part XXXII., p. 48, Plates 134, 135 (1917). At p. 49 I have stated that it has been recorded from Albury, but the specimens are not quite satisfactory, nor are the Tumbarumba ones normal Although these localities (especially the former) are close to Victoria, they make one pause before inferring that, on this evidence, the species occurs in Victoria. Professor Ewart tells me that he cannot find any trace of this specimen (quoted by Mr. Baker; C. Walter was an old collector of Mueller's); "all our records for *dealbata* are from New South Wales localities only." I cannot therefore accept it as a Victorian plant at present.

E. FASCICULOSA, F.v M.

The history of the confusion of this species with *E. paniculata*, Sm., is given at C.R., Part XIV. p. 140, with Plate 61 (1912). It is not a Victorian plant, so far as we know.

E. paniculata, Sm., is not a Victorian plant, in spite of my reference to it in C.R., XIII., 106, following Mueller. Mueller's

record is from Gippsland, a very unlikely locality for *E. fasciculosa*, F.v.M., which see.

Those who desire to see a figure of this species will find it in F.F., Part VIII., Plate 30 (1904).

E. HAEMASTOMA, Sm.

I do not know of a Victorian locality.

E. PIPERITA, Sm.

See C.R., Part X., p. 299, Plate 45 (1908). As regards its claim to be a Victorian species, see pp. 300, 302, 304. I think it is a doubtful Victorian plant at present. See also F.F., Part XXXIII., p. 38, Plate 124 (1909).

E. POPULIFOLIA, Hook.

An excellent Victorian Eucalyptus observer, Mr. Harry Hopkins, says in "Advance Australia," for October, 1909: "Another species not common in Victoria, but which extends eastward through New South Wales and to Queensland, according to von Mueller, is *Eucalyptus populifolia*—the poplar-leaved or shining box tree. I have not seen it west of the Tambo River." He has sent me specimens from Orbost and the Tambo River, whose foliage simulates that of *E Baueriana* a good deal Although I reject it as a Victorian plant on the evidence, I somewhat confidently look forward to its collection in the Mallee country, or north-west.

For a figure of *E. populifolia* see my F.F., Part XLVII., Plate 176 (1912).

E. STRICTA, Sieb.

See C.R., Part XL., p. 336 (1920). It has not been proved to be a Victorian species so far.

E. WOOLLSIANA, R. T. Baker.

The Seymour plant is, I am satisfied, *E. hemiphloia*, var. *microcarpa*. As I am of opinion, already expressed in C.R., Part XI., under *E. odorata* and *E. hemiphloia*, that *E. Woollsiana* is a mixture of species, and as a full explanation requires additional figures, it cannot be fully dealt with at this place. It will be dealt with in Part XLVII., C.R.

[PROC. ROY. SOC. VICTORIA 34 (N.S.), PT. II., 1922.]

ART. XI.—*The Rotifera of Australia and their Distribution.*

BY J. SHEPHARD.

[Read 8th September, 1921]

Investigation into the Rotiferon Fauna of Australia has so far been carried on by but few observers, but at widely separated points. The neighbourhood of Melbourne has probably received most attention. About Sydney, Brisbane and Adelaide collecting has been done, and outside these capitals scattered districts in Victoria and New South Wales have been worked, the most remote contribution being a colonial form obtained by Sir Baldwin Spencer when with the Horne Expedition to Central Australia.

It is quite true that the number of species of rotifers attributed to any country are so far proportionate to the amount of search that has gone on. It appears that much more work should be done before a full comparison can be made with the rotiferon fauna of other countries.

The time when an extensive investigation into this group of animals will be completed appears so remote that it may be useful to report progress in the hope that further enquiry may be stimulated. Adhesion to the classification of Hudson and Gosse, as the generally accepted one up to the present, seems desirable in spite of a recent proposed alteration. It may be well to point out that a departure from this system and of the accompanying understanding not to go back beyond Ehrenberg in the search for priority, will certainly retard work in this group in the outlying parts of the world, although such course may be in accordance with a strict interpretation of the rules relating to priority of names.

The records which may be regarded as reliable give a result in numbers as follows:—

Rhizota	39	species	of	9	genera.
Bdelloida	54	„	„	16	„
Ploima—					
Fam. Illoricata	57	„	„	17	„
„ Loricata	79	„	„	19	„
Scirtopoda	1	„	„	1	genus.

In all there are 230 species.

Many more species have been seen, but the above can be regarded as the total number of certain identifications, and is the work of some seven or eight observers.

The habitat and occurrence of rotifers in Australia present features differing from those of Europe and America. The dryness of the country in the summer months obliterates nearly all the pools in the early spring, so that the summer is the quiescent period for rotifers. The so-called "winter egg" which in Europe carries the species over the cold season is here a "resting egg" bridging over the warm weather. In the district south of Melbourne, known to botanists as the "heath country," there is an area with a surface largely formed of blown sand, in the hollows of which numbers of pools exist in winter and disappear entirely every summer, yet they yield a varied collection of these animals. Among the forms occurring in this way are a few species of unique characteristics which so far are unknown elsewhere. These all belong to the genus *Lacinularia.*

In the main part of Hudson and Gosse's "Rotifera" only one species of this genus was mentioned—*L. socialis,* a world-wide form—and in the supplement to the work there was a brief description of *L. pedunculata,* an Australian animal. Since the appearance of that work, eight more species of *Lacinularia* have been described, and of these seven, *L. elliptica, L. elongata, L. megalotrocha, L. pedunculata, L. racemovata, L. reticulata,* and *L. striolata* are from specimens found in Australia, and the remaining one, *L. natans,* Mr. Rousselet states, was found near London once only. This species is, however, extremely plentiful in Victoria, and has been found plentifully near Brisbane. Of these species two, *L. elliptica* and *L. elongata,* were recorded later from South Africa and France respectively. This still leaves five species unknown outside Australia. All these eight species of *Lacinularia* are colonial forms, and are therefore conspicuous and easily found, the smallest clusters being discoverable by the naked eye, while two, *L. pedunculata* and *L. striolata,* form clusters of thousands of individuals, and are objects as readily discernible as a fallen wattle flower, and a third, *L. reticulata,* occurring as it does in colonies on the surface of the mud, has been seen in masses over a square inch in area.

Mr. Rousselet in his paper on the "Geographical Distribution of the Rotifera" states that "it is not possible to speak of any

typical or peculiar Rototorian fauna for any continent, zone or region." I submit that in view of the facts now stated in regard to the genus *Lacinularia* and its mode of occurrence, this decision is premature. There can be no doubt that man's activities are efficient agencies for the distribution of rotifers, and may largely account for the wide diffusion of species now observed, but, if isolated occurrences of the five species described and recorded solely from Australia should be discovered, it seems reasonable to regard them as most probably due to those agencies.

As above stated, the forms are conspicuous, and besides all appear in enormous numbers at times. The free swimming colonies fill the pools, it being impossible to dip an ounce of water free from them. The method of development indicates adaptation to the peculiar climatic conditions. The resting eggs, having lain dormant throughout the summer in the dried mud in hollows, on the fall of rain in early winter develop simultaneously with the eggs of other animal and vegetable organisms. Generally, the plant forms are the first to mature, and thus a supply of food is ready for the swarms of minute animals which follow. The early part of the wet season is the time when in a given pool a particular species often predominates almost to the exclusion of all others. This is specially noticeable in the five species, *L. elliptica*, *L elongata*, *L. striolata*, *L. natans*, and *L. reticulata*.

L striolata practises a unique method of multiplication of colonies, which strongly suggests a special adaptation to the environment. The clusters are sedentary, being attached by a peduncle to aquatic plants, and a single colony may consist of thousands of individuals. The growth of the colonies in this species is not due to successive generations of individuals taking their places in the colonies alongside their parents. The method is as follows: After the rain forms a pool the resting eggs of the previous season germinate, and give rise to free swimming individuals, which come together and form small colonies. Immediately in these colonies, the individual members of which are all females, parthogenetic eggs appear, and hatching out in the gelatinous nidus, the newborn rotifers swim away and combine with similar forms from other colonies to form a new cluster; thus a colony consists only of the animals which initiate it, and the colonies become successively larger as the increase in number goes on. This swarming process goes on until the food supply

is exhausted, and at this stage males appear, followed by the formation of resting and presumably sexual ova, these latter being destined to endure throughout the summer until another rainy season again originates the process.

In view of these facts of adaptation to the special conditions of the Australian climate, the so-far exclusive occurrence of the majority of species of one genus, and the methods of multiplication of so peculiar a character, it seems too hasty to assume that rotifers are entirely cosmopolitan in their distribution. At least it must be granted that there are indications of an approach to an indigenous character such as strongly marks the general flora and fauna of this continent.

[Proc. Roy. Soc. Victoria 34 (N.S.), Pt. II., 1922].

Art. XII.—*Local Rain Producing Influences under Human Control in South Australia.*

By E. T. QUAYLE, B.A.

(With Map)

[Read 8th September, 1921].

In a previous paper the author has brought several lines of proof to show that various influences in Victoria were having a marked effect upon the rainfall. The chief of these were the substitution in the Mallee of crops and grass for the drought-resistant forest covering, and irrigation, both natural and artificial. One of the proofs relied upon was a map showing for all stations available the departures of the mean rainfall for the decade 1910-1919 from that of a standard 30-year period, 1885-1914. This appeared to show remarkably well the effects looked for, that is, all areas in lee of, or S.E. from one with increased cultivation or irrigation, showed a marked increase in the rainfall, up to 15 per cent. in the most favoured cases. But there were increases just beyond the Victorian border in South Australia for which no explanation was available. In order to see if any light might be thrown upon this, I undertook the task of analysing the South Australian rainfalls in the same way as I had already done those of Victoria and the southern and western parts of New South Wales. This revealed an area of marked rainfall improvement, lying south-east from Lake Torrens, and embracing more especially the eastern portions of the Upper North, where it ranged as high as 20 per cent. This area seems to be continuous with the Victorian areas of improvement, in which case we have a long strip lying north-west and south-east, stretching from the sources of the Murray to Lake Torrens, or at least to the highlands of the Upper North, giving a total length of over 600 miles. It was found too, that as in New South Wales, north from this area the rainfall had markedly decreased, deficiencies of 14 per cent. being common, and that to south-west, as in Victoria, the areas

dependent mainly upon "southern" disturbances for their rains showed a very definite decrease. We therefore have in South Australia and New South Wales a belt of country some 250 miles long and 70 miles wide which has had during the decade, in spite of a general downward tendency elsewhere, a decided increase in its rainfall

Another improved strip, again lying N.W. and S.E., and therefore parallel to that just defined, begins on the west side of Spencer Gulf at Waratta Vale, some 40 miles north of Port Lincoln, and includes the foot of Yorke Peninsula and the eastern half of Kangaroo Island.

In looking for causes for these rainfall improvements, it is evident that irrigation can be disregarded. No serious attempts at irrigation have been made in South Australia, excepting, of course, those now in progress on the Murray, which in any case could only help Victoria.

We have to consider, therefore, only the alteration in the surface; the substitution of crops or grass for Mallee scrub or other drought-resistant vegetation, and the variations in the water supplies of the great inland lakes. The settlement of the country has brought about considerable changes in these respects. Unfortunately I have so far been able to get but little direct information more than that contained in the Statistical Registers, which deal only with production.

It is interesting to note that in general where throughout the 30-year period, 1885-1914, land occupation was complete and but little progress shown in cultivation and stock raising, there is also no improvement in the rainfall in lee of the area. This applies to the southern half of the country between St. Vincent's Gulf and the Murray River. County Adelaide, for example, has been practically stationary from 1884 to 1918 as regards horses, cattle, sheep and the area under cultivation.

Going northward, we find Counties Gawler and Light have made only very trifling increases in stock, though the years 1909-18 show a 35 per cent, increase in the area under cultivation. The Lower North (lat. 33-34) also shows an almost stationary condition as regards stock, but considerable progress in agriculture, the increase in area amounting to nearly 60 per cent. There is a definite rainfall improvement of up to 9 or 10 per cent. in lee of these areas, or over a N.-S. strip of 120 miles long, and about 20 miles wide.

The Upper North (lat. 31½ to 33) was so badly hit by the droughts of 1895-1902, that its cultivated area declined from 800,000 to about 500,000 acres, or by nearly 40 per cent., and it also suffered stock losses from which it took many years to recover. Even yet this division, though showing rapid increase of late, carries scarcely more stock than in those early years, 1885 to 1890, and less than in 1891 and 1892. As regards the effects from growing crops, it is evident that this cannot be great, at all events in the Upper North, unless we take into account the greatly increased vigour of growth due to recently improved cultivation methods, and the use of fertilisers. These certainly tend to produce far more vigorous growth during the spring months, and favour later sowing.

A not improbable factor is, however, the clearing of the country, which improves convectional action, and therefore makes thunder-showers of more likely occurrence. In spite of the stationary or retrograde conditions of agriculture, the needs of stock have probably made progress in ring-barking and scrub-clearing continuous so that the area of cleared hilly country should be steadily increasing.

Influence of the Lakes.

The foregoing are probable contributory factors, but the lie of the area of greatest rainfall improvement points distinctly to Lake Torrens as its chief origin. With regard to the state of this Lake or of L. Frome, which should share the same fortune, I have been able so far to get little definite information, though various people, some with 40 or 50 years' experience of the interior, most of whom were interviewed by Mr. Bromley, the State Meteorologist, have contributed their impressions All agree that Lakes Torrens and Frome are rather immense salt pans than true lakes, and only rarely show any extensive areas of water surfaces. Mr. Price, of Frome Downs, writes as follows: "There are about 20 big creeks which, after rain in Flinders Range, empty into Lake Frome. This water all disappears in a few hours after the creeks cease running. The Lake is always very boggy, and no animal can cross it." Lake Torrens appears to behave much in the same way.

It would seem then that the water discharged from time to time into these depressions goes to dilute a semi-liquid mass, the water constituent of which being intensely salt and of high

specific gravity, is capable of holding in suspension, and also preserving much of what the creeks, when flooded, bring down. The rate of evaporation would naturally be influenced by the amount of dilution. The lake beds could hardly remain at all porous, and owing to the absence of vegetation and animal life, either within the lake area or on the shores, the choking of the pores must be permanent. That is, the fine muddy particles have brought about the condition aimed at by the Mallee farmer who "puddles" his dam. Lake Eyre, being fed from such vast areas, is more truly a lake, and, according to Mr. Allen, of Warrina Station, is now fairly full, but that happens only rarely. Mr. T. Hogarth, who has had 50 years' experience of the district, has only seen the Lake filled twice during that time. It also forms such a boggy environment as to make the water unapproachable under ordinary conditions. This and mirage effects make it hard to ascertain the state of this or any of these lakes.

Run-off Improving.

It seems highly probable on various grounds that both Torrens and Frome are now impounding much more water than formerly. Experiences in Victoria go to show that settlement is effecting great changes in the run-off from the various river drainages. The clearing off or killing of the timber has made the springs better water providers, and the destruction of the trees, coarse grasses, reeds, etc., on the stream banks has caused the channels to deepen. Forty or fifty years ago the upper portions of the Avoca River and its tributaries consisted of shallow, and often grassy, channels, connecting large, deep water holes, providing permanent reservoirs, and through their large total capacity presumably holding back very considerable quantities of water which otherwise would have been poured on to the lower plain country. These water holes provided a paradise for anglers, especially school boys. They now hardly exist. Deep gutters have been cut from pool to pool, and the final result is a thread of water, almost constant in volume, with scarcely a pool of sufficient magnitude to shelter a decent sized fish. There is, of course, some compensation in the fact that the more permanent flow of the springs, the better protection from the sun, and the lessened demands of riverside vegetation cause more water to reach the river's final destination, and I anticipate

that these factors are operating in connection with the lakes of South Australia.

Mr. W. E. Abbott, of Wingen, New South Wales, in various papers read before the Royal Society of New South Wales, has given many emphatic proofs of the effects of ring-barking in increasing the flow from springs, and making permanent the flow of streams previously only intermittent.

The Willochra Creek.

The chief source of water supply for Lake Torrens seems to be the Willochra Creek, which drains a belt of country extending south as far as Booleroo, and north as far as Hawker, two stations about 70 miles apart The area of this can hardly be less than 2000 square miles. It is, of course, rather a dry area, the average annual rainfall ranging from 12 inches at Hawker, to 16 inches about Booleroo, but is liable to have quite a wet climate for months at a time. For instance, at Booleroo periods of six months' duration in 1916 and 1917 gave 17½ and 15 inches respectively; 5 months gave 12 inches in 1920, and 13 inches in 1921; 4 months in 1909 gave 13 inches; 3 months gave, in 1889, 12½ inches; in 1893, 11.6 inches; in 1908, 10 inches, and so on. Hawker has similar records: 14 inches in 3 months in 1889; 13 inches in 4 months in 1892; 15.2 inches in 5 months in 1916; 13.3 inches in 4 months in 1917; 20.4 inches in 6 months in 1920; and 14 inches in the first 5 months of 1921. These are quite sufficient to turn the creek into a very considerable river during these periods.

"Run-off" Rains.

Failing actual data, I ventured on an estimate of the variations in the water supply of Lake Torrens, based upon the probable run-off from the Willochra Creek basin, using the rain stations Booleroo, Quorn and Hawker. This required some assumptions of a very general character. The basin being well drained, I adopted as "run-off" falls in winter, anything over 2 inches for the first month, and 1½ for each consecutive month following, and in summer 3 inches for the first month, and 2 inches for each following month. This probably errs on the side of moderation, for falls of 2 or 3 inches are not uncommon in one day, but at all events it provides a fairly definite scale by which to compare the periods. The first really wet period was from

1889 to 1893, giving a total "run-off" rain of 31.0 inches. This was followed by a long dry spell of 12 years, 1894 to 1905, giving only 15½ inches altogether. The drought ended in 1902, but the "run-off" rains for 1903 to 1905 were small, only totalling 6.0 inches. From 1906 to 1910, a wet period, the "run-off" was 21½ inches; from 1911 to 1915, a very dry five-year period, only 2.4 inches; from 1916 to 1917, two very wet years, 15.7 inches; from 1918-1919, only 1.4 inches, and during 1920, and up till May, 1921, a very wet period, 17.0 inches. The lake should, therefore, have been large in 1894, and, say, 1895, in 1911 and 1912, and in 1918 and 1919. At the present time it should contain more water than at any time "within the memory of the oldest inhabitant."

Droughts Minimised by Evaporation from Lakes.

In order to see if the records tend to confirm the theory that the evaporation from Lake Torrens is a large factor in bringing about the improved rainfall to south-east, or in lee of it, and between the lake and, say, Wentworth and Mildura, I tabulated the annual rainfalls at ten of the principal stations in this area, as well as at five to southwards, where no improvement is evident, and of five to northwards beyond the influence of Lakes Torrens and Frome as rain producers. The first (Group A) consists of Hawker, Warcowie, Holowiliena, Wilson, Belton, Paratoo, Yunta, Cavenagh, Johnburgh and Waukaringa; the second (Group B) of Port Augusta, Quorn, Wilmington, Arden Vale and Port Germein; the third (Group C) of Blinman, Beltana, Mt. Lyndhurst, Leigh's Creek and Wooltana. The percentage departures from the average rainfall during the years following periods of lake water accumulation were as follow:

	1894	1895	1911	1912	1918	1919
Group A.	+19	−4	+7	+13	+2	+12
„ B	+2	−18	−23	+10	−19	−8
„ C	+1	+18	−8	−16	−25	−22

These figures show the apparent advantage to Group A from lake evaporation to be very marked, and they also show that the gain so striking during the decade 1910-1919 could not be attributed to the accidental excesses of wet years. The fact that owing to its position, Group B should have the most reliable rainfall gives the comparison additional significance.

Lake Frome.

This lake, when full, perhaps does not cover more than half the area of Lake Torrens. It is, nevertheless, then a very large body of water with a surface of greater extent even than Port Phillip Bay. It is filled from practically the same drainage area as Lake Torrens, and, therefore, should behave in much the same way. Unfortunately, there are no stations at all near it on the south-eastern side. About twelve miles due south from it, however, there is Frome Downs Head Station, which shows an increase of 27 per cent. for the decade 1910-19, over its average rainfall of 5¾ inches. At a radius of about 100 miles in a south-easterly direction are Boolcoomatta, Cockburn, Thackeringa, Broken Hill, Purnamoota, Poolamacca and Corona. These stations had in only two cases complete records for the period reviewed, but these records were capable of being "patched" without any large probability of error. All but one show marked improvements in the last ten years' rainfall, the percentages being respectively: +9, +11, —5, +13, +4, +3, and +23 The minus result was the most doubtful; but taking a mean of the lot, we get an average increase of 8 per cent.

Other Systems.

As regards the probable water accumulation in Lakes Eyre and Gairdner, or in the numerous minor lake beds of South Australia, nothing can at present be said. Lake Gairdner is probably under somewhat similar influences, but Lake Eyre derives its supplies from sources too remote, and an area too vast to permit of any hasty generalisation. It may be noted, however, that in connection with all these lakes there are indications of benefit during the decade 1910-1919 for all stations within areas south-east from them, and to some extent to south and south-west from them also. This, of course, is in accordance with results already shown by the analyses of the rainfalls on the eastern and western shores of the head of Spencer Gulf. Both gained from the waters between, but only in the case of the former could any great inland gain be expected, the general drift of the atmosphere being eastward.

The Cultivation of Eyre Peninsula.

Reference has been made to the improved rainfall over the eastern half of Kangaroo Island, the southern half of Yorke

Peninsula, and at Waratta Vale, in the east of Eyre Peninsula. In view of the expanses of sea included, it might seem absurd to connect these areas and to attribute the rainfall increases to any land improvements, but it is nevertheless true that such would be quite in accordance with what has been already described for other regions. Waratta Vale lies south-east from an area which has undergone rapid improvement during the last decade. In 1890 the counties Flinders and Jervois could only show 23,000 acres under cultivation, and it was only in 1906 that 100,000 was reached, but from 1910 to 1918 the average cultivation acreage was over 320,000 acres. This means much clearing of Mallee scrub. In Yorke Peninsula, too, the increase was very marked, amounting to more than 200,000 over the average acreage from 1890 to 1900, or from about 130,000 to 350,000 acres This latter has recently become, owing to the use of fertilisers and improved methods generally, one of the most important granaries of South Australia.

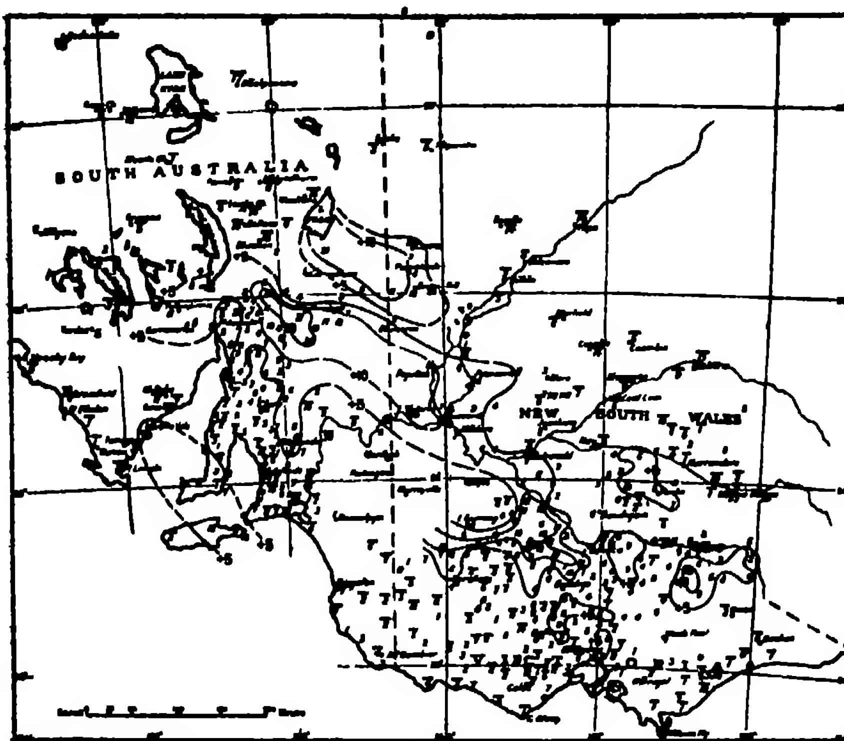
Cultivation in the South-East and East.

The most rapid development in South Australian cultivation during recent years is in the counties Albert, Alfred, Chandos and Buccleuch, south of the Murray, and adjoining Victoria. Prior to 1908 the cultivation was almost negligible, less than 100,000 acres altogether In 1916 their total was over 670,000 acres Any rainfall improvement due to this would, however, mainly affect the adjacent Victorian Mallee areas, most of which are at present quite undeveloped. It is more than probable, however, that the improved rainfall shown about and south from Lake Hindmarsh is due to that. Moreover, in the recently developed Mallee areas along the Murrayvale-Ouyen line, the rainfall has proved better than was expected.

Explanatory Notes.

The objection might be raised that the great length of the rain improvement strip S.E from Lake Torrens is out of all proportion to the area of the lake. This may be met by remembering that there may be many re-evaporations and re-descents as rain of the moisture obtained from the lake. Every moistening of any area helps the rain prospects for that in lee of it. Another point is that the hours of most active evaporation and precipitation are not the same. Thunderstorm rains are heaviest and

most frequent towards evening, and widespread rains of tropical origin seem to be helped by the atmospheric cooling during night-hours. Thus the effects of lake evaporation might be postponed for several hours, and be first felt one or two hundred miles away.



Map showing percentage departures of the mean rainfall of the last 10 years, 1910-1919, from that of the 30 year period, 1885-1914.

Rainfall Incongruities.

The apparently haphazard mixing of small plus and minus departures may often be due to difference in elevation and aspect of the rain stations used. For example, south from Lake Torrens and west from the Willochra valley is some fairly mountainous country on which the bulk of the rain would be caused by "southern" disturbances and accompanied by wind, whereas on the lower ground or in lee of the ranges, the rains would be more of "monsoonal" type. The latter would show the influence of the lakes, the former might not. Then, of course, we have to put up with the occasional neglect of the rain guage, observers' carelessness, varying faults in the exposure of the gauge, etc.

Evidences from Decennial Rainfall Maps.

In order that the decade 1910-1919 should not have to carry the whole burden of proof that rainfall is affected by changes in the surface of the country, I plotted the rainfall departure in similar fashion for each of the three decades, making up the standard period. The results are most interesting and quite in accordance with the theory.

1885-1894. Over the inland areas of South-eastern Australia, or east from a line joining Spencer Gulf, Lake Torrens and Lake Eyre, this was a remarkably wet decade. While this helped to fill the lakes in South Australia, and increased the floodings of the Murray and its tributaries, thus producing evaporation areas and increasing the rainfall in the favoured areas, the generality of the abundant rainfall, which was largely of direct tropical origin, tended to obliterate these local preferences. We can look, therefore, for smaller percentage gains over the areas usually favoured. This shows up quite well on the map. The following strips of country showed less gain than the country on either side: (1) Along the Murrumbidgee from its junction with the Lachlan, almost up to Narrandera; (2) From Yarrawonga to Deniliquin and Piangil, or along the upper Murray and Edwards; (3) From Shepparton, along the Murray to Wentworth; (4) From Wentworth to Lake Torrens. As regards the river areas, this tends to confirm the reality of the rainfall increases shown by the isohyets on the average annual rainfall map to obtain along the Murray and the principal streams through the Western Riverina When the map was constructed, in 1910, this was regarded as a freak result. The actual percentage departures from average are as follows. Beginning with the plain country north of the Murrumbidgee, and ending with the Victorian plain country south from the Murray River we get: Plains (northern) +28, Murrumbidgee River +19, Plain +24, Edwards and Murray River (upper) +20, Plains +23, Murray River (lower) +17, Plains (Victoria) +24.

For the decade the greatest percentage increases are over the north-west and central plain country of New South Wales, where some reach 40 per cent. The dominantly tropical origin of the rains is obvious.

Stations along the Darling from Pooncarie to Wilcannia show very consistent increases of over 30 per cent., which may have

been partly due to the filling of the rarely filled lake system along the Darling.

1895-1904. Drought was predominant during this decade, and tropical influences on the whole ineffective. The very severe three years' drought which began in July, 1895, must have dried up the moisture in the lake beds, and there was no appreciable run-off to renew it until 1903. This being so, we should look for the area partially dependent upon the lakes for its rainfall to show the greatest deficiencies during this period. This is shown very well, the minus isopleths for this decade showing much the same contouring as the plus for 1910-1919. This reversal is even shown along the southern and south-eastern borders of the Mallee, which is at it ought to be, the Mallee still being largely wilderness or unimproved.

1905-1914. This being a transition period, both for agricultural development and lake storage, its isopleths do not stand out as those for 1910-1919, but similar tendencies are strikingly shown. The agricultural progress of Eyre Peninsula is apparently reflected in rising rainfall to south-east of the areas, that is, on the foot of Yorke Peninsula and the eastern end of Kangaroo Island; the Western Wimmera is gaining by the clearing and cultivation of the South Australian Mallee across the border; and the rainfall from Wentworth to Lake Torrens is distinctly on the up grade.

It supplies, moreover, another exceedingly neat proof of the effectiveness of the floodings from the Murray River system in increasing the rainfall on the river flats, the rainfall isopleths over the Riverina and northern Victoria, which were minus, giving an almost exact copy of those for the wet decade, 1885-1894, which of course were plus.

All three decades thus bring their evidence to support in various ways the theory that the rainfall is largely affected by local influences. The coincidences in areas affected are very striking.

Another point made clear is that the decennial rainfall oscillations are far greater east from the South Australian lake system than west of it, which is itself fairly strong evidence that the variation in the lake supplies is a large disturbing factor. The figures also suggest for inland New South Wales a rainfall dependence upon previous downpours in Queensland, and especially those tending to fill Lake Eyre.

The following table shows the decennial rainfall variations at two groups of stations, one on the western, the other on the eastern side of the lake system:—

Western Group.	1885 to 1894.	1895 to 1904	1905 to 1914.	1910 to 1919.
Oodnadatta	+5	−1	−4	−15
Anna Creek	+0	−8	+9	−9
William Creek	−10	+2	+8	−12
Stuart's Creek	+5	−14	+8	−1
Arcoona	+5	−3	−2	−5
Coondambo	+1	−9	+8	+2
Means	+1	−6	+4	−7

Eastern Group.	1885 to 1894	1895 to 1904	1905 to 1914.	1910 to 1919.
Warcowie	+11	−19	+8	+11
Holowiliena	+13	−25	+13	+23
Belton	+14	−24	+10	+11
Paratoo	+19	−32	+13	+20
Frome Downs	+14	−31	+18	+27
Cockburn	+21	−20	−1	+11
Means	+15	−25	+10	+17

Seasonal Forecasting.

The effect on this cannot be ignored, since well-filled lakes are a guarantee that for a few years, two at least, the climate of the areas south-east from them will be greatly ameliorated—this can be taken account of by farmers and pastoralists, the latter more especially. For example, whatever the severity of any general drought over south-eastern Australia during the next two years, its effects should be distinctly alleviated over a large area south-east from Lakes Torrens and Frome, as well as over all northern Victoria, and some of the Riverina.

General Deductions.

The strength of the preceding reasoning lies, of course, in the general and striking accordance of the results obtained. Taken in conjunction with Victorian experience, these are so numerous that the case for definite rainfall improvements due to local sources may be regarded as definitely proved. It is the evidence we accept to demonstrate the rainfall effects of rising ground proximity to the ocean, prevailing winds, etc., for which we do not need many years' records. This solves the problem of what

should be done to revive the "dead heart of Australia." Without any far-seeing policy or consciously-directed effort on our part, it is probable that the great inland lakes will gradually store more and more water; but surely the process is worth hastening. For example, it might even be worth while to keep Lake Torrens at least partially supplied from Spencer Gulf. An improvement of 20 per cent. in the rainfall of 20,000 square miles of country is worth much money, a practical example of which is to hand. The counties Granville, Hanson, Herbert and Lytton, which form only a part of the improved rainfall area under discussion, in 1918 carried 387,000 sheep and nearly 11,000 cattle and 4000 horses, numbers practically equal to those of 1891, the record stock year for Australia.

Storage Gains from Clearing.

The preceding study teaches two important lessons. One is that the clearing away of the forest covering from the whole of our hilly areas, at all events, of those portions of the inland foothills and mountain slopes in any way suitable for pasturage, is distinctly beneficial, not only to its stock-carrying capacity, but to inland climatic conditions as well, inasmuch as it greatly increases the amount and constancy of the flow of the rivers It thus releases from day to day for storage in inland lakes and reservoirs vast quantities of water which otherwise would be thrown into the mountain atmosphere, and to a large extent cross the hills, eastwards and southwards, without condensation, and so escape. A reason for thinking this is that the transpiration and evaporation from the leaves of the upland trees must be little or none during the times of atmospheric saturation, but are probably most vigorous during the bright sunshine and drier air of the anticyclonic periods. This seems contrary to the behaviour of the drought-resistant vegetation of the plains, which has to adapt itself to extreme conditions, but it is not really so. By mountain vegetation, more especially that of Victoria and New South Wales, the strain of drought and heat is rarely felt and so definite drought resistance is not often called for; whereas saturated air is a rare experience to the Mallee eucalypts and their fellow strugglers, and heat and aridity so often have to be endured that transpiration, if not checked, would exceed the powers of their roots to make good. From the former, evaporation is inopportune, both in time and place—from the latter in time.

Need for a National Policy.

The other is that every facility should be given to settlers to make payable use of our remoter inland areas, even to the extent of national financial, and other sacrifices, recognising that this occupation of the interior is a sure way of ameliorating the climate for the rest of the continent or, at all events, for all those areas in lee of the outpost belt. Obvious methods are, of course, the adoption of some zone system for railway fares and freights, and the establishment of the greatest water schemes the continent is capable of. The addition of four or five inches of rain to the average annual rainfall of our dry areas, especially if the addition were maintained during drought periods, would mean multiplying their value by 20 at least.

It is evident, too, that the further inland the water can be stored or utilised, the more extensive will the area benefited climatically be.

Tropical Origin of Inland Rains.

Keeping Lake Torrens full would evidently help to keep Lake Frome full also, the latter draining a very large proportion of the country benefiting. If we consider the origin of these inland rains, and the processes at work in their production, this statement will prove not so extravagant as it seems at first sight. The mapping of the daily departure from normal of the minimum temperatures at all stations over the northern half of the continent shows that practically all the inland rains are of tropical origin. That is, rain never falls, say, in the neighborhood of Lake Frome without previous evidence of a drift towards this region of a body of relatively warm, moist air from some northerly point, most often, presumably, from the north-west. Condensation is usually the result of latitudinal cooling, and may take place without the assistance of any storm developments, though it most often occurs in the north-eastern front of "southern" disturbances which naturally accelerate the southward drift of the air in front of their troughs. It is occasionally helped too by what appears to be displacement upwards of this warm air by the cold, dry air of an anticyclonic system moving inland from some point south of west. But whatever the outside accelerating influences, it is certain that evaporation from any considerable body of water in the path of this southward-moving air will have a powerful effect in deciding where and when precipitation shall begin. Assuming, say, that we have, as these

minimum temperature departures so often show, a wide flow of air coming inland from the neighborhood of Wyndham or Port Darwin, this may carry its water vapour without much addition from the dry plains beneath for perhaps 2000 miles before it shows by its cloud production that through gradual cooling the limit of its moisture-holding capacity is nearly reached. Precipitation may not begin till the Murray is reached, or even the highlands of the Divide, but it might begin considerably earlier, and perhaps two or three hundred miles further inland if it encountered the disturbing effect of buoyant, moist air rising from such a source as L. Eyre or L. Torrens. That is, for large inland areas, the influence of the lake evaporation helps to determine not only the amount of rain, but perhaps more often whether there shall be some rain or none. In a sense it may be partly a question as to when and where "the tap is to be turned on."

Australia's Increasing Aridity—a Partial Cause.

In these papers, reference has already been made to the different ways in which vegetation may affect rainfall. It has first been shown that the substitution of growing cereal crops or grass for Mallee scrub causes a marked increase in the rainfall of the districts in lee of the improved area, especially in spring. Then irrigation was proved to show some similar effects. And now I have been able to show greater effects still, from the recently increased water storages in the great lakes of South Australia, the benefits being almost on a continental scale. For the increasing lake water storage, the changing character of the natural drainage channels, and the lessening of the water demands of the forest covering under pastoral occupation have been shown to be important factors. We may now logically apply these results to the solution of a larger problem.

The early settlers in the eastern interior of this continent found inland perennial vegetation to consist first of a belt of vigorous growing trees with abundant foliage occupying the more elevated upland regions; next on the foothills and adjacent plains the hardier types of the same with smaller leaf surface; then further inland stunted and distinctly drought-resistant types, such as Mallee eucalypts, bull-oaks (casuarinas), etc.; and further inland still, under severer conditions, salt bush, blue bush, etc.

Now it is more than probable that in the struggle for existence our perennial vegetation has been its own undoing. The very means it has been compelled to take for its own protection have made the climatic environment progressively worse. Whether distinctly drought-resistant or not, it must regulate transpiration so that it is never unduly accelerated with the result that the hot spells leading up to rainy conditions find inadequate response in evaporation from the country beneath, while the comparative coolness of the shaded land surface helps to prevent convectional action and lessen the frequency of thunder-showers. Moreover, the blocking of the water channels and the prevention of erosion, the drying of the subsoil, and consequent lessened flow from springs owing to the large moisture requirements of the trees all tend to hold the water up against the eastern mountain slopes, where its evaporation is comparatively ineffective in rain production, and away from the depressions in the interior where its evaporation would be most effective in rain production. Hence the increasing dryness of the interior and the gradual contraction of the belt of perennial vegetation towards the inland slopes and foothills.

It therefore follows that pastoral occupation must be assisting to reverse the process of dessication. The destruction of the forest trees in the more favoured belts, and the substitution of grass and annuals for the more drought-resistant trees, and even for the scrub and herbage perennial growths inland, are aids in the local production of rain, while the firming of the surface soil and the formation of tracks to water by stock help to make surface drainage better. Then the tapping of artesian and sub-artesian water supplies, though probably only a minor influence, must help to increase atmospheric vapour supplies and tend to rain production. Much injury is in parts unfortunately being done to the fine surface soil covering of the plains, but where the plough is used this is arrested.

The filling of Lake Eyre though a most attractive proposition, is perhaps an impracticable one, but water storage and irrigation for large portions of the north-western and western divisions of New South Wales seem possible, and if carried out wholeheartedly, would surely have beneficial results to the inland climate of that State almost incalculably great. The addition of two inches of rain annually seems quite possible, and that would carry wheat cultivation westwards to the Darling River.

Proc. Roy. Soc. Victoria 34 (N.S.), Pt. II., 1922].

Art. XIII.—*The Development of Endosperm in Cereals.*

By MARY GORDON, B.Sc.
(Caroline Kay Scholar).

(With 9 Text Figures.)

[Read 13th October, 1921].

The early stages of endosperm development are accurately described in the text-books and other publications dealing with the subject; but it is assumed that the process of free cell-formation, by which the first layer of endosperm arises, is continued throughout the development of the seed, and that all the endosperm cells are formed by the development of cell-walls around the nuclei that lie freely in the protoplasm of the embryo-sac. The earlier stages in the development of the endosperm of Burmannia—a monocotyledon comparable with the cereals in endosperm development—have been described by Ernst and Bernard (1). They have shown that the nuclei formed by the division of the first endosperm nucleus, do not become immediately enclosed in cell-walls, but they line the embryo-sac, and later cell-walls develop between them. From this stage Ernst and Bernard did not trace the method of endosperm development any further; they apparently took for granted that all the endosperm was formed in a similar manner.

The mature grains of cereals agree in the main points of structure, having the bulk of the endosperm composed of large cells filled with starch grains, and a peripheral layer, or layers in the case of barley, containing no starch, but protein material in the form of aleurone grains. These cells also contain large nuclei, whereas the nuclei of the inner cells are much disorganised.

In a paper—The Endophytic Fungus of Lolium—published in the proceedings of the Royal Society of Victoria, Dr. McLennan (2) has described the outer layer of the endosperm of *Lolium temulentum* as an endospermic cambium, which is active only on its inner surface, where it cuts off brick-shaped cells which assume an approximately spherical form as they attain their adult size. They remain thin-walled and constitute the starchy endosperm. As the grain approaches maturity, the

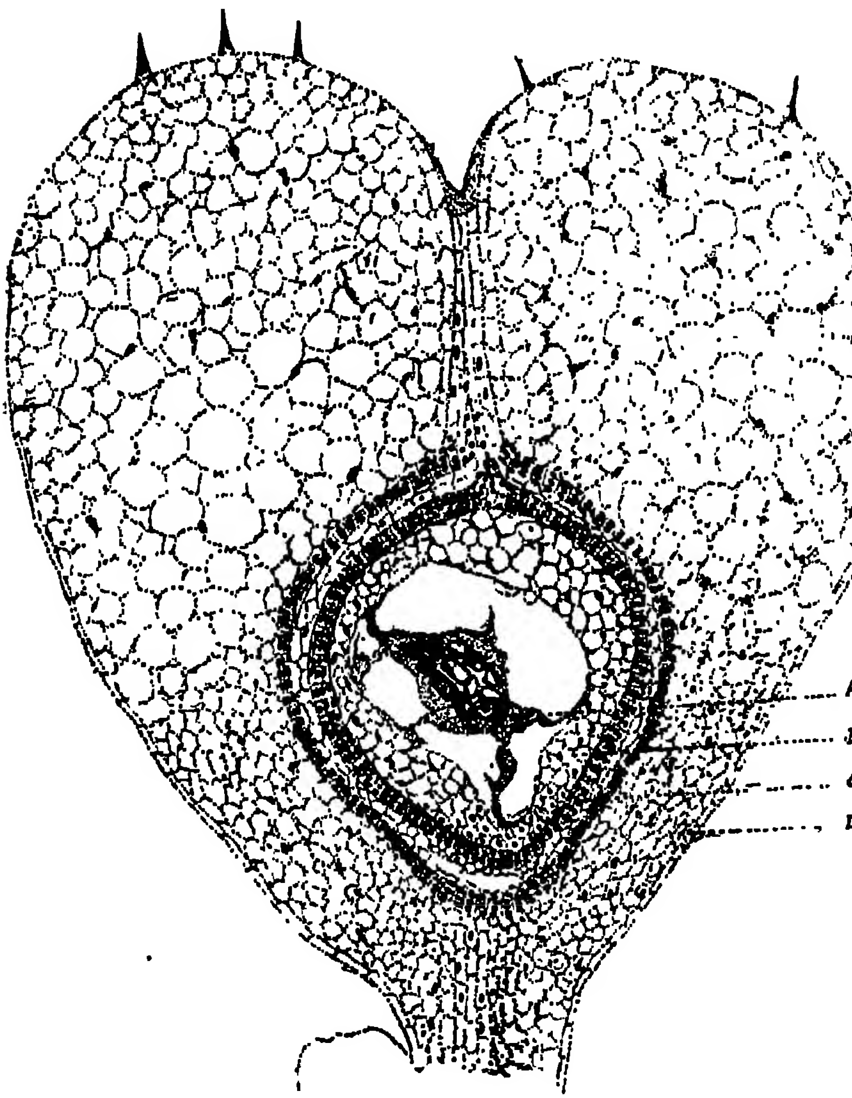
outer layer ceases to divide, but it persists in the seed as the aleurone layer. Even when the cells of this layer are resting, and have become filled with reserve food, their nuclei remain large and intact. At this stage the walls of the aleurone cells become considerably thickened, and this supports the cambium theory, since cambial cells entering on a period of rest show thickenings on their walls which are either partly or wholly removed when such a layer recommences its activities.

I have attempted here to trace the development of the aleurone layer and the starchy endosperm in the more common cereals, and to show whether the starchy endosperm is developed from the aleurone layer or not; that is, to prove whether the aleurone layer is really an endospermic cambium or not.

The ovules of barley, wheat and oats were taken at various stages of development, and fixed in either Carnoy's or Bouin's fixing solutions. Considerable difficulty was experienced in fixing the oat grains, owing to the hairy nature of the pericarp, which prevented the fixing solution from penetrating the seed. An attempt to fix some seeds under reduced atmospheric pressure was not any more successful, since the more volatile constituents of the fixing solutions tended to vaporise under the reduced pressure, and so pass out of the solution. The only way to ensure rapid and complete penetration of the fixing solution is to pierce the seed-coat, and even then the inner endosperm of ripe grains generally breaks in cutting. Microtome sections were cut of the grains embedded in paraffin, and the sections were stained with Haidenhain's Iron Haematoxylin as it rendered the nuclei in mitosis very distinct. In all three cases the development was found to be practically identical, except that the ripe barley grain has—as is well-known—an aleurone layer several cells deep, whereas wheat and oats have a single layer only. In the "Annals of Botany," Miss Brenchley has published two papers describing the earlier stages in the development of the grains of wheat and barley (3) and (4). They show how the first endospermic nuclei are formed by the division of the secondary nucleus of the embryo-sac, but the later stages in the endosperm development are not described.

A longitudinal section of a young ovary is shown in Text Fig. I.; it is not cut directly through the centre of the seed so that the embryo does not appear in the section. In the centre

of the embryo-sac are the first-formed endospermic nuclei, which have been formed from the secondary nucleus after fertilisation. These appear as a group of free nuclei lying in the protoplasm of the embryo-sac. This, according to Goebel,

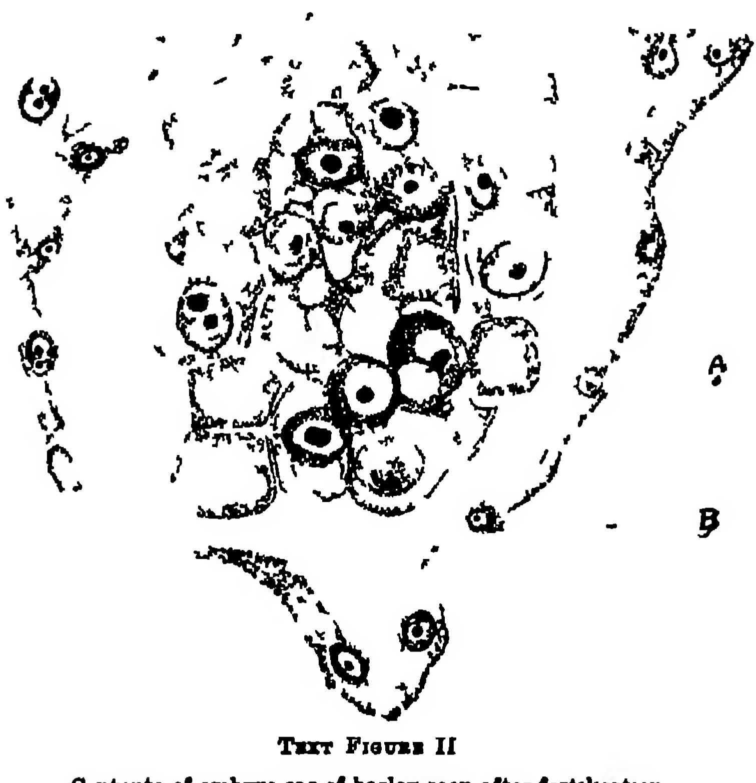


TEXT FIGURE I.

Longitudinal section of young ovary of barley after fertilisation.

A—First endospermic nuclei.
B—Nucellus.
C—Ovular integuments.
D—Wall of ovary—later pericarp.

occurs in all monocotyledons and most of the dicotyledons Some of the nuclei later pass to the walls of the embryo-sac, where they form a single lining layer (Text Fig II) Portions of the protoplasm around the walls each containing a nucleus, are cut off by cell walls, so that the embryo sac becomes lined by a single layer of cells This section is also cut to one side of the ovary so that the embryo is not showing



TEXT FIGURE II

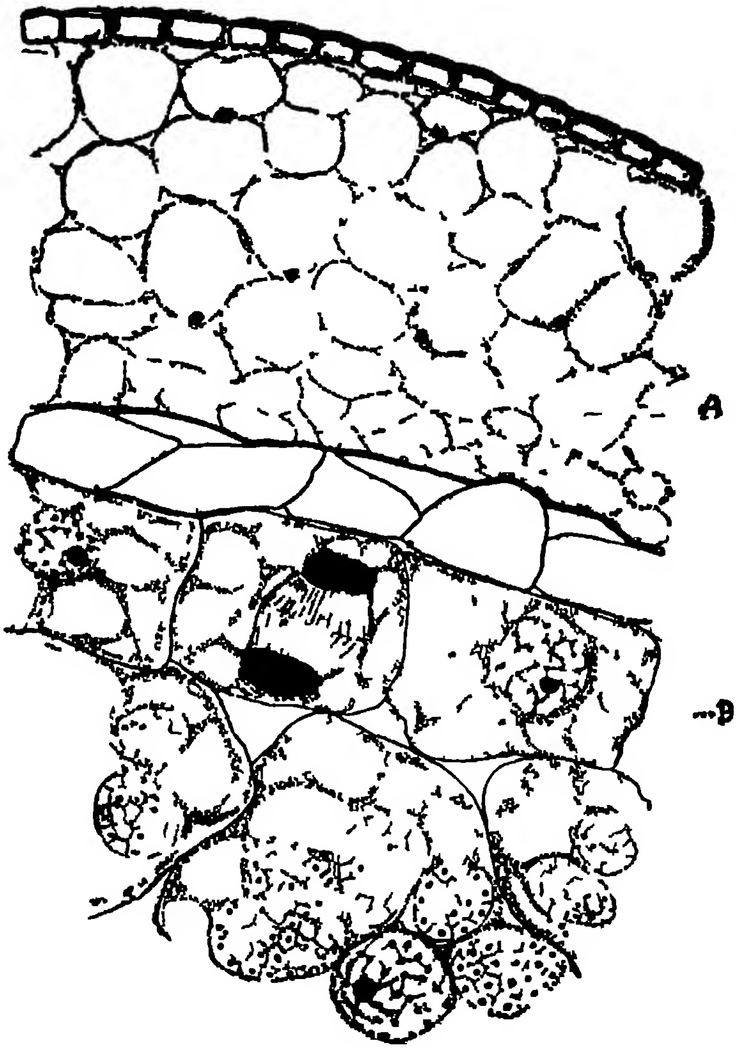
Contents of embryo sac of barley soon after fertilisation

A—Group of large vacuolate nuclei in embryo sac

B—Wall of sac lined by protoplasm and nuclei

A typical section through an oat grain in a later stage of development than the preceding sections is shown in Text Fig III One nucleus of the outer layer of endosperm cells is undergoing mitosis and there are also two resting nuclei of the same layer apparent After the nuclei divide transverse cell walls are formed between them and the inner cells do not as a rule divide again but they enlarge considerably and become filled with starch The nucleus of the outer cell remains large

and retains its power of dividing until the grain is almost mature Aleurone grains then appear in the cells of the outer



TEXT FIGURE III

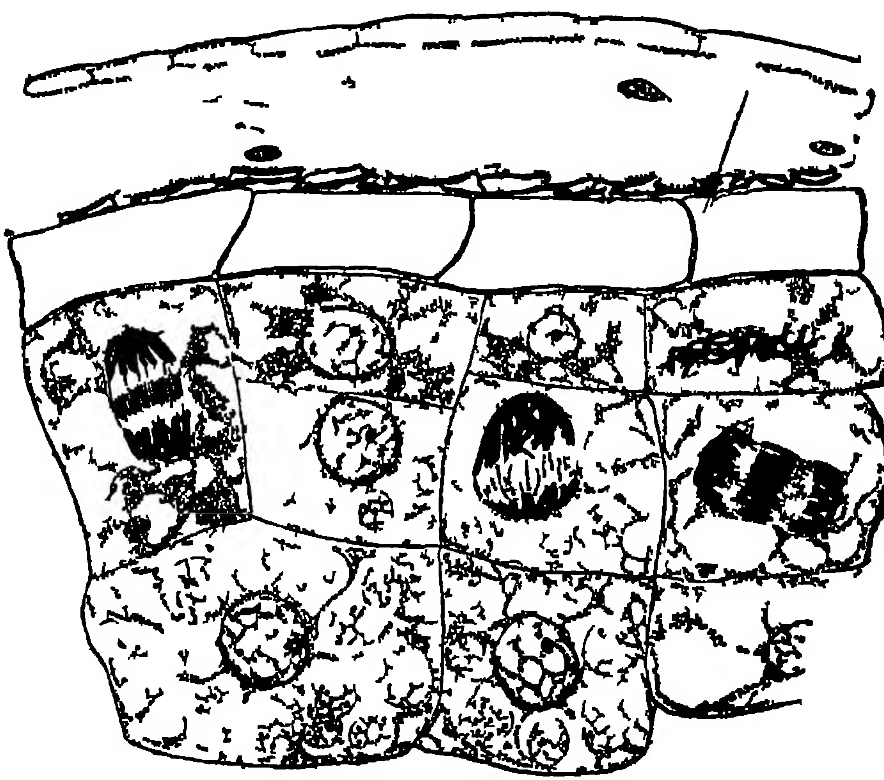
Transverse section of oat grain

B—Endosperm ic cambium shows two resting nuclei and one in mitosis
A—Degenerating cells of walls of ovary

layer The starch of the endosperm of oats is not in the form of grains as in wheat and barley, but appears as rounded groups Each group is made up of a number of centres, of which there appear to be more in the older than in the younger groups, but

it is possible that the number of centres is the same in all of the groups and only show up clearly when starch is deposited in the

Occasionally nuclei are to be found dividing in the endosperm two or three cells below the actively dividing surface layer (Text Fig IV) This is not inconsistent with the idea of a cambium as cells formed from a cambium frequently divide



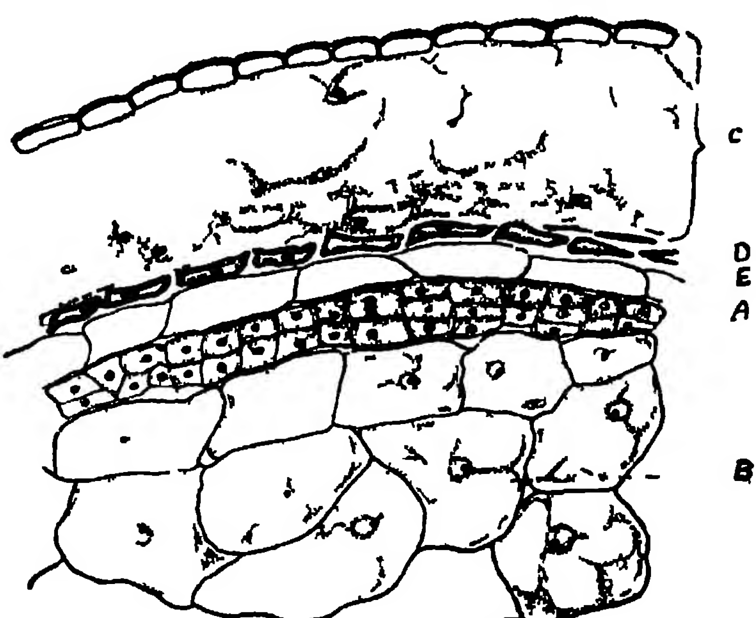
TEXT FIGURE IV

Transverse section of young oat grain showing ole of first and second layers n m tos s

again In the endosperm of barley binucleate cells sometimes occur (Text Fig V) and it is possible that after the original nucleus divided the two daughter nuclei lie close together in the cell and are prevented from separating by the presence of starch which soon becomes deposited in the cell This also would prevent the formation of a new cell wall thus giving a single binucleate cell

TEXT FIGURE V
Binucleate endosperm cell

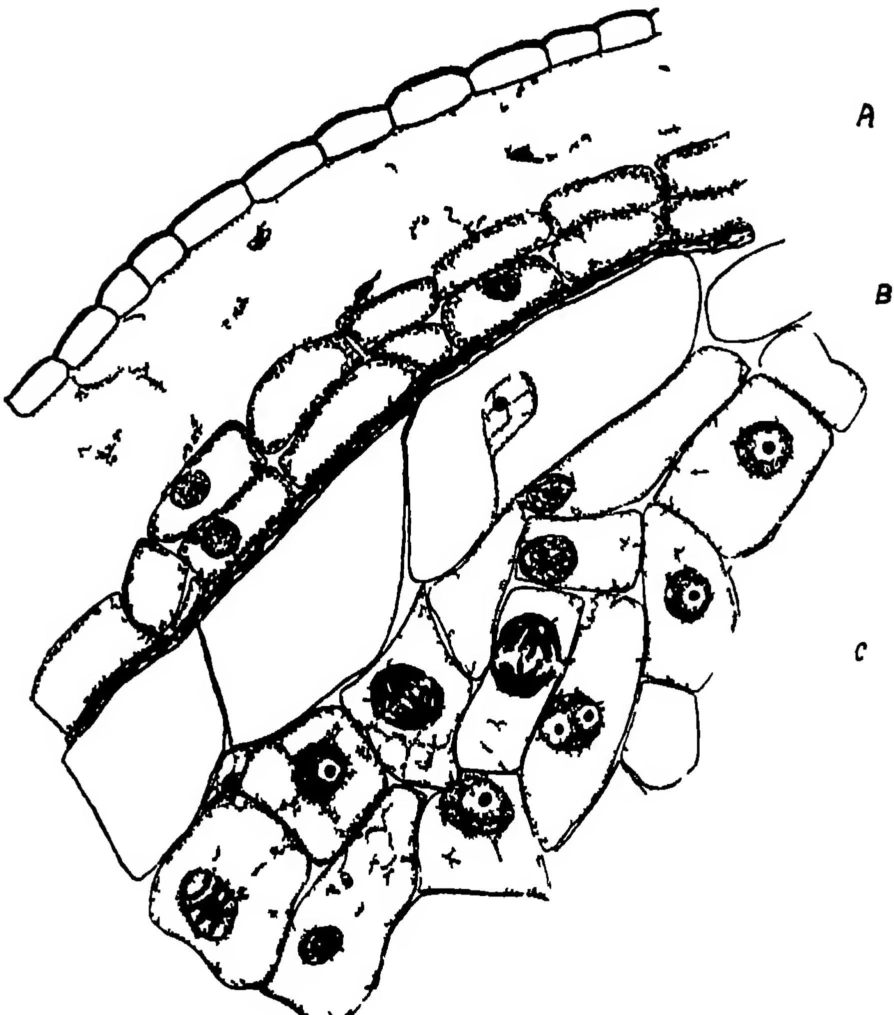
A later stage in the development of the barley grain is illustrated by Text Fig VI it shows the transition of the surface



TEXT FIGURE VI
Transverse section of barley grain

A Outer dividing layers of endosperm
B—Starchy endosperm cells
C—Pericarp
D—Testa
E—Remains of nucellus

layers of the endosperm from a dividing cambium to the resting condition of the adult grain when the cambial cells become packed with aleurone grains to form the aleurone layer Another section of a barley grain at about the same stage of development



TEXT FIGURE VII

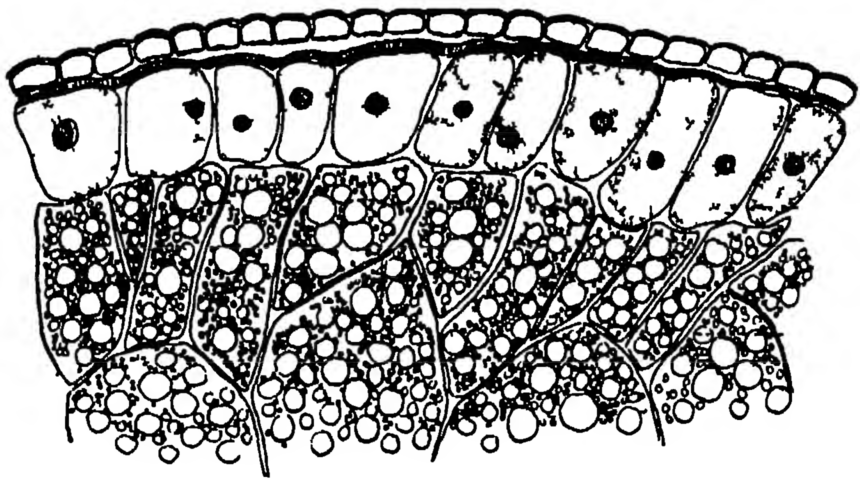
Oblique section of barley grain

A—Degenerating wall of ovary
B—Remains of nucellus
C—Dividing nucleus

as Text Fig VI but which has been cut obliquely and is more highly magnified is shown in Text Fig VII The distinction

between the dividing cambial layer and the general endosperm is not so well marked but the details of cell division are clear in the outer layer which appears several cells deep owing to the obliqueness of the section

Surrounding the endosperm there is a single layer of large cells the contents of which have practically disappeared this is the remains of the nucellus (5) which has been displaced and absorbed by the developing endosperm It appears as a layer of disorganising cells in the young grain but has disappeared when the grain is ripe Beyond this there is a layer of silica which



Text Figure VIII

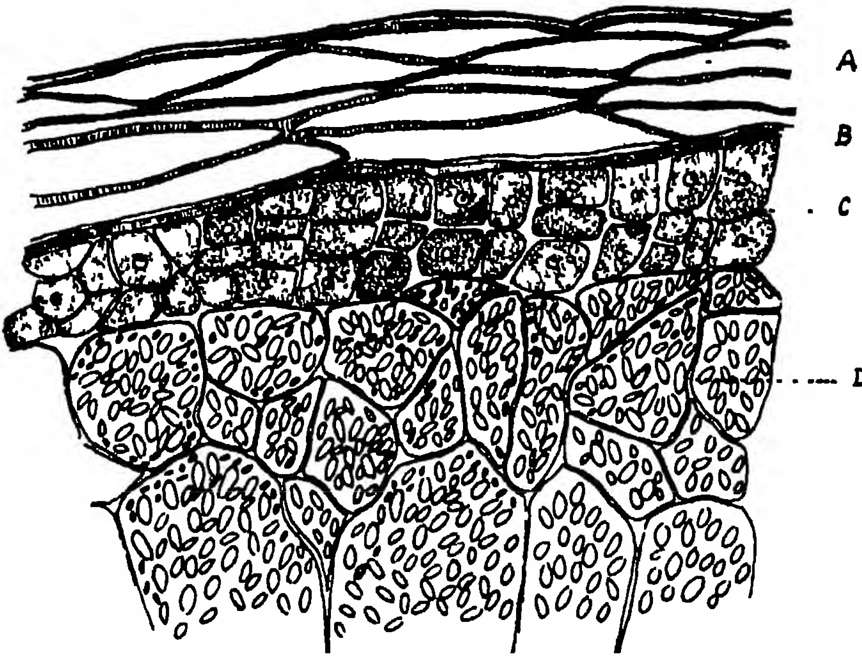
Transverse section of ripe oat grain

A—Single aleurone layer
B—Endosperm

was probably deposited in the outer wall of the embryo sac—this forms the so called testa which is not really a seed coat since it is devoid of any cellular structure

The ovary wall contained starch which was absorbed by the embryo during its development (Text Fig VI) As the starch is used the cells become empty and the nuclei can be seen in process of degeneration Later the cell walls thicken and develop into the pericarp of the ripe grain The final stages where the resting cambium appears as the aleurone layer are shown in a transverse section of an oat grain (Text Fig VIII),

and of a barley grain (Text Fig. IX.). With the exception of occasional cases in which dividing nuclei occur just beneath the superficial cambial layer, no cell divisions take place in the starchy portion of the endosperm, which is entirely derived from segment cells cut off from the cambium.



TEXT FIGURE IX

Transverse section of ripe barley grain

A—Pericarp
B—Testa
C—Aleurone layer several cells deep
D—Endosperm (starch)

The fact that the aleurone layer differs from the starchy endosperm in being a resting layer, enables us to understand several of its peculiarities. Thus Stoward (6) has shown that the removal of the aleurone layer from the endosperm leads to a marked fall in the output of carbon dioxide by the grain, and indicates approximately the comparatively large share of the total respiratory output that is due to the aleurone layer. Injury to the seed alone would tend to cause an increased respiratory activity manifested as a wound reaction. Although

the cells of this layer are packed with aleurone grains, they also contain large, well-defined nuclei and a quantity of protoplasm. The nuclei of the starch-containing cells of the endosperm are partly disorganised and the cells contain very little protoplasm. The greater respiratory activity of the aleurone layer may be accounted for if it is to be regarded as a resting cambial layer.

It has also been demonstrated that there is present in the outer layers of the endosperm of wheat, rice and other cereals, a substance the deficiency of which causes polyneuritis in birds and Beri-Beri in man (7). Funk gave to this substance the name vitamine, and supposed it to be contained in cells rich in protein. It is found in the tissue of the embryo of cereals, as well as in the aleurone layer, but it is deficient in the starchy endosperm. Since vitamines are usually especially associated with growing tissues, it is not surprising to find that in this layer—a resting cambial layer—they should be especially abundant, whereas in endosperm cells derived from it, which degenerate into starchy receptacles, vitamines should be deficient or absent.

Brown and Morris (8) advanced the view, from their experiments, that the amylaceous endosperm of Granineae represented a "dead storehouse of reserve material." This conclusion does not refer to the endosperm as a whole, but only to the amyliferous cells, the possibility of the aleurone cells possessing vitality being left open. Haberlandt (9) regarded the aleurone layer as a glandular digestive organ

The following table, taken from the report of a committee of the Royal Society of London, indicates that there are vitamines present in the whole grain of the cereals, but the flour which is obtained after milling contains no vitamines, as they are removed with the aleurone layer.

VITAMINES IN PLANTS.

Plant.	Fat soluble A (Antirachitic)	Fat-soluble B (Antineuritic (Anti Beri Beri)	Unstable C Antiscorbutic
Wheat and whole grain of cereals	+	+	0
White wheat flour	0	0	0
Cornflour	0	0	0
Polished rice	0	0	0
Malted barley	+	+ +	+ +

Summary.

(1) The first formed endospermic cells of cereals are derived from the secondary nucleus of the embryo-sac.

(2) The nuclei so formed pass to the walls of the embryo-sac, when they form a lining layer. Later the nuclei become enclosed by cell walls, so that the embryo-sac is lined by a single layer of cells.

(3) The lining layer of the embryo-sac assumes the character of a cambium, which produces segment cells only on its inner surface.

(4) The segment cells formed by the division of the cambial cells enlarge, remain thin-walled, and become packed with starch, to form the starchy endosperm.

(5) After the cells of the endospermic cambium have ceased to divide, they become filled with aleurone grains and the cell-walls thicken. It then forms the aleurone layer.

(6) The greater respiratory activity of the aleurone layer and the presence of vitamines in it are the natural results of its being a resting cambium.

(7) Whether it can be awakened to further activity during germination remains for future investigation.

The foregoing research was carried out in the Botanical Department of Melbourne University, under the direction of Professor Ewart, and represents the work done as Caroline Kay Scholar.

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Proc. Roy. Soc. Victoria 34 (N.S.), Pt. II., 1922].

Art. XIV.—*Present and Probable Future Distribution of Wheat, Sheep and Cattle in Australia.*

By R. G. THOMAS, B.Ag.Sc., Dept. of Agriculture, Victoria.
(Communicated by A. E. V. Richardson, M.A., B.Sc.)

(With 3 Text Figures.)

[Read 10th November, 1921]

Australia being essentially an agricultural and pastoral country, it was thought that considerable interest would attach to any method which would graphically and accurately represent the distribution throughout the continent of the units of the main primary industries; further, that such might give some insight into the possibilities of extending the various industries beyond their present boundaries, and the direction in which such extension is likely to take place. With this object in view the accompanying maps were prepared, showing the distribution of the units of the three principal primary industries—viz., sheep, cattle and wheat—in Australia (referring here and in all statistics to the continent of Australia, excluding Tasmania). The method adopted has been to represent a certain number of head of stock, or acres of wheat, by a dot placed on the map as near as possible to their situation, as indicated by official statistics; this gives a more accurate representation of the distribution than can be obtained by differential shading or coloring. Each dot represents respectively 5000 acres of wheat, 10,000 head of sheep, and 1000 head of cattle; these quotas are small enough to show a relatively sparse distribution, yet without showing too great an area where the dots run together, and no differentiation can be shown in the areas of concentration of the respective units. The statistics used were those for the year 1918-19, being the latest typical season for which details of all the States were available at the time the work was commenced. Similar maps have been prepared by the United States Department of Agriculture, but it is hoped that so far as Australia is concerned those now published are not only based on later records, but more accurately represent the actual distribution of the units throughout the country.

Embodied in the maps is also meteorological data relating to rainfall and temperature, which is necessary for adequate consideration of the factors affecting the present distribution and probable extension of the industries. The data given consist of various isotherms (i e., lines of equal average mean annual temperature) with the 5, 10, 20, 30, 40 and 60 inch isohyets (i.e., lines of average annual rainfall), in the case of the two stock maps; and for the wheat map, the 5, 7.5, 10, 15 and 20 inch lines of winter rainfall, or more strictly the rainfall during the growing period of the crop, i.e., April to October, inclusive.

Acknowledgment is here made to the Government Statists of the various States and the Department of Home and Territories for the furnishing of the statistics necessary to the work, and to the Commonwealth Meteorological Bureau for meteorological data used.

Wheat.

The total area sown to wheat for grain and hay in Australia, for the season 1918-19, was 9,647,433 acres, and of this total New South Wales contributed 3,227,374, South Australia 2,571,208, Victoria 2,488,810, Western Australia 1,336,502, and Queensland 23,539 acres. This area represented approximately 3 5 per cent of the total area that year sown to wheat throughout the world. Until the last four seasons, which have shown a decline due to abnormal labour and marketing conditions, there had been a steady expansion of wheat-growing in Australia, her production increasing from 1.6 per cent. of that of the world in 1906-07, to 4.8 per cent. in 1916-17, and it is hoped to show that there is ample room for this extension to continue.

Considering the distribution of the area shown by the map (Plate I.), the most striking feature is the very limited extent of the wheat-growing country. There is, indeed, a distinct wheat belt forming a crescent-shaped area some distance inland from, and approximately parallel to, the south-eastern coast line, approaching and broken by the coast line as the latter turns northwards along South Australia, and continued again as a similar belt back from the south-western coast of Western Australia.

The factors limiting the distribution of the wheat acreage may be classed under two heads—natural and political or economic. The chief natural factors are the soil and climatic conditions of rainfall and temperature. The soil within any climatic region

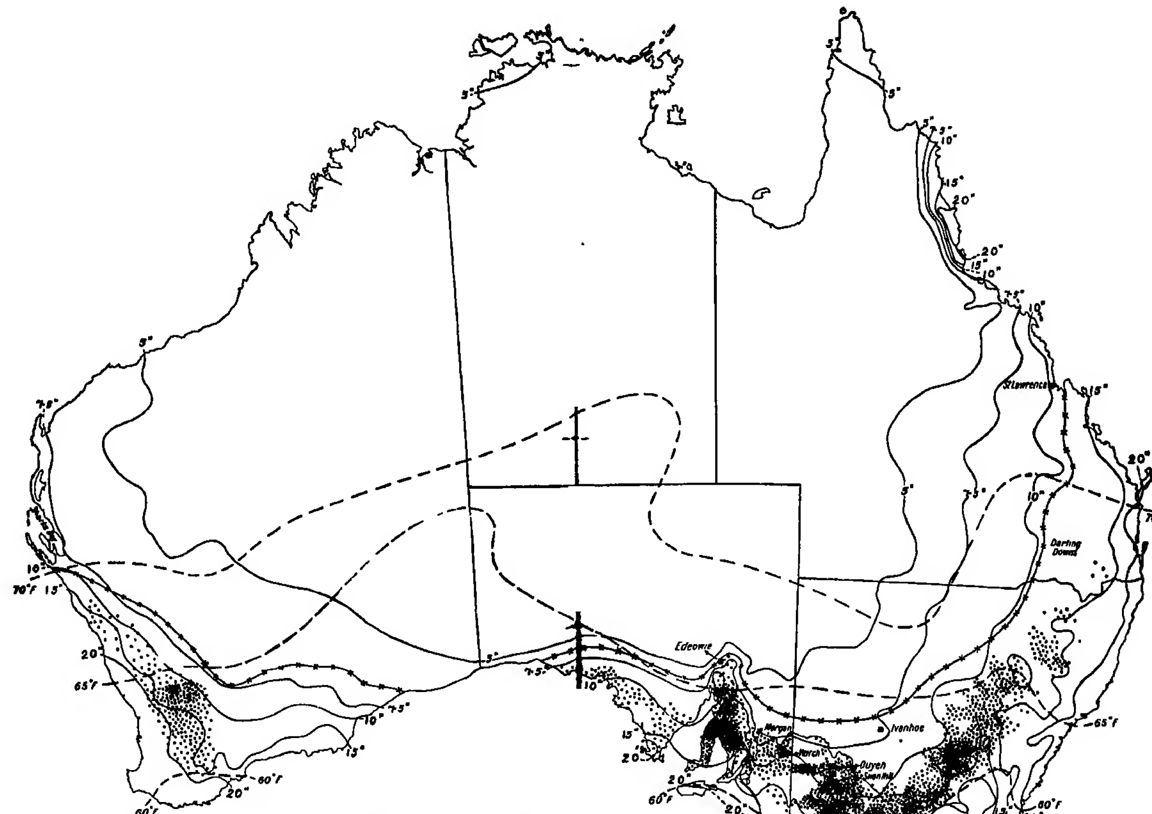

Fig 1.—Distribution of Wheat Acreage in Australia

Each dot represents 5,000 acres
Lines of average "winter rainfall" shown thus ————
Lines of average mean annual temperature shown thus — — — —
Lines showing probable inland limit of wheat belt as indicated by climatic conditions comparable to the present furthest inland areas under crop, shown thus ×–×–×

will vary widely in fertility, but it is safe to say that, within the regions to be indicated as suitable, and not yet used for wheat production, though there are areas of low soil fertility, there are many thousands of acres of which the soil is eminently suited to the growth of wheat. As regards the other two factors, rainfall and temperature, the rainfall both in its total amount and incidence in respect to the growing period of wheat, is far the more important Temperature, in fact, can be almost disregarded as a limiting factor; there is no extensive area of cultivable land in Australia which is actually too cold for the growth of wheat, though in our colder districts other conditions combine to make it less profitable to grow wheat than other crops. Similarly, though wheat is not grown north of the 70 deg. isotherm, there is a considerable area north of this line climatically similar to the wheat-growing areas of India.[1] Here, again, it is the question of the degree of profitableness as compared with other agricultural and pastoral pursuits under our present conditions of development, rather than temperature, which limits the extension of the wheat area in a northerly direction. At the same time there is evidently an optium condition of temperature for wheat in Australia, for practically the whole of the area sown to wheat is situated between the 60 and 65 deg. F. isotherms, there being a marked coincidence between the 60 deg isotherm and the southern limit of the wheat belt.

Considering the distribution of acreage in relation to the more important factor of rainfall, the rain of importance to wheat is that falling during the growing period of the crop, i.e., April-October, inclusive, the rain falling during the summer being largely lost by evaporation, and also sometimes tending to reduce the wheat yield by causing lodging of the crop and the spread of rust Therefore the lines of rainfall shown are those for this period. It is seen that practically all our wheat is now grown between the lines of 7.5 and 15 inches of winter rainfall. In Western Australia there is certainly a considerable area between the 15 and 20 inch lines, but here settlement is so sparse that more intensive agriculture has not yet pushed the wheat belt back into its true sphere in the dry farming regions. In South Australia, Victoria and New South Wales, the 15-inch line corresponds very closely with the southern boundary of the wheat belt, this line approximately separating the dry farming

[1]Vide Griffith Taylor, "The Australian Environment"

area from the closer settlement country where more intensive farming is possible. The 10-inch line of winter rainfall has usually been regarded as the safe limit for wheat growing, but in South Australia and Victoria wheat is grown over a very considerable area inside this line, extending to, and even passing the 7.5-inch line. The wheat-growing districts about Edeowie and Morgan in South Australia, and immediately south of Mildura in Victoria, are beyond the 7.5-inch line of winter rainfall; while between the 10 and 7.5-inch lines are the older settled Mallee districts of Veitch, Ouyen and Swan Hill, where wheat growing has been an established and successful industry for over 10 years. It can be fairly assumed then that country having a winter rainfall of somewhat under 7 5 inches, of reliability equal to that in the areas indicated, and an average temperature not greatly above that of these areas, is capable of growing wheat under our present methods of cultivation and economic conditions of price of wheat, land and labour. In New South Wales the 10-inch line has not yet been passed, and it would seem that in the northern portion of the State it does indicate the probable limit of the wheat belt. The greater variability of the rainfall, and the higher temperature, causing increased loss by evaporation, make a given average rainfall less efficient in crop production here, than a similar amount in the cooler and more reliable rainfall areas in the southern portion of the State.

It is difficult, indeed, to indicate the ultimate inland limits of the wheat belt in Australia, for with improved, drought-resistant varieties, and better methods of cultivation, new areas are being brought under crop which but a few years previously it was thought impossible to successfully cultivate. This increasing efficiency will, it is hoped, continue. But even with our present knowledge there is ample room for expansion before what may be termed the probable limits of the wheat belt in the more immediate future are reached. The line shown thus: —x—x—, is an arbitrary line, indicating what appears, from climatic considerations, to be such probable limit, and it is seen to enclose immense tracts beyond the present limits of development. Commencing on the 10-inch winter rainfall line, south of Shark's Bay, W.A., where the variability of the rainfall, is too great to warrant an extension of the 7.5-inch line, it passes west beyond the 7.5 line, as the more reliable rainfall along the

southern coast is reached. In this State alone we see a vast area of country awaiting exploitation, the greater portion of it having a winter rainfall equal in reliability and total amount to the well-developed wheat belt in Victoria. Along the west coast of South Australia this reliability of rainfall still holds, and here again might be expected a development beyond the 7.5-inch line, as has already occurred in the regions of less reliable rainfall about Edeowie. Passing over the extension of the belt north of Spencer's Gulf, the line turns southwards and runs somewhat north of the Murray, and approximately parallel to the 7.5-inch line to about Ivanhoe, N.S.W., enclosing the immense tract of fertile Riverina country. Thence the line passes north-east beyond the 10-inch line, and north to St. Lawrence on the Queensland coast. As previously stated, the greater variability and higher temperature make the actual rainfall less effective than in the southern areas; hence this marked departure from the 7.5-inch line. As to the probable northerly limits of the belt, although there is a considerable area shown with a sufficient winter rainfall, and where wheat can doubtless be grown, yet it seems unlikely that any considerable amount will be grown north of the Darling Downs, the high temperature, ample rainfall, and its summer incidence combining to make wheat less profitable than other crops.

The present wheat belt, as shown, extends over an area of some 124 million acres, of which only one acre in fifteen, or a total of nearly eight million acres was under wheat in 1918-19. Since none of this is mountainous country, and wheat is everywhere the principal crop, it might be expected that the area at present sown will be about trebled before this belt is utilised to anything like its full capacity. But, apart from this area, there is in the probable wheat belt indicated further inland an area of some 138 million acres. Assuming that this area can be developed only to the same extent as at present obtains in the Victorian Mallee, which is indeed a reasonable assumption when it is remembered that 20 years ago the advisability of abandoning the Mallee for settlement was seriously considered, and that even now but a relatively small portion of it is developed to any extent, this area would then carry a population of some 570,000, or 2½ people per square mile.

Aggregating the two areas, we have a wheat belt of over 260 million acres. Of this we might ultimately expect at least 40

million acres under crop each year; this, with an average yield of 10 bushels per acre, would give at least 400 million bushels annually, which, at the present Australian rate of consumption per head of population, and deducting the necessary quantity required for seed, would supply flour sufficient for the requirements of over 50 millions of people. It is not to be thought that even this is considered the limit of our possibilities as a wheat-producing country. It is a conservative estimate of the possible production from this area only, based on a low proportion of land under crop and a low average yield per acre. In the closer settlement country, wheat can be grown in rotation with other crops under conditions of intensive agriculture; the acreage sown in these areas would not approach that of the wheat belt, but with a higher average yield per acre the production would be appreciable.

It is clearly evident that the factors determining the present actual limits of the wheat belt are economic and not natural ones. The limits on the coastal side of the belt are determined by questions of profit in competition with other crop and live stock industries; inland, practically in all cases by transport facilities. The most striking instance of this is in the undeveloped areas of Mallee land on either side of the Ouyen-Murrayville railway line. Again, the decided boundary in South Australia and New South Wales where the wheat belt stops at the Murray River, coincident with the limits of railway facilities. We have a long way to go in extending this, the chief present economic limit to the development of the wheat industry, before we approach the natural boundaries indicated above.

Sheep.

In the year under consideration, the sheep population of Australia numbered some 85,194,503, and of these New South Wales claims 37,381,874, Queensland 18,220,985, Victoria 15,773,902, Western Australia 7,183,747, South Australia 6,625,184, and Northern Territory 8,811 head. This number represents approximately 16 per cent. of the world's sheep, emphasising Australia's position as a leading sheep and wool-producing country.

Examining the distribution of the sheep throughout the continent (Plate II.), it is seen that the belt of maximum concentration is in South-eastern Australia, and that it coincides roughly with the wheat belt, the main departure being in the

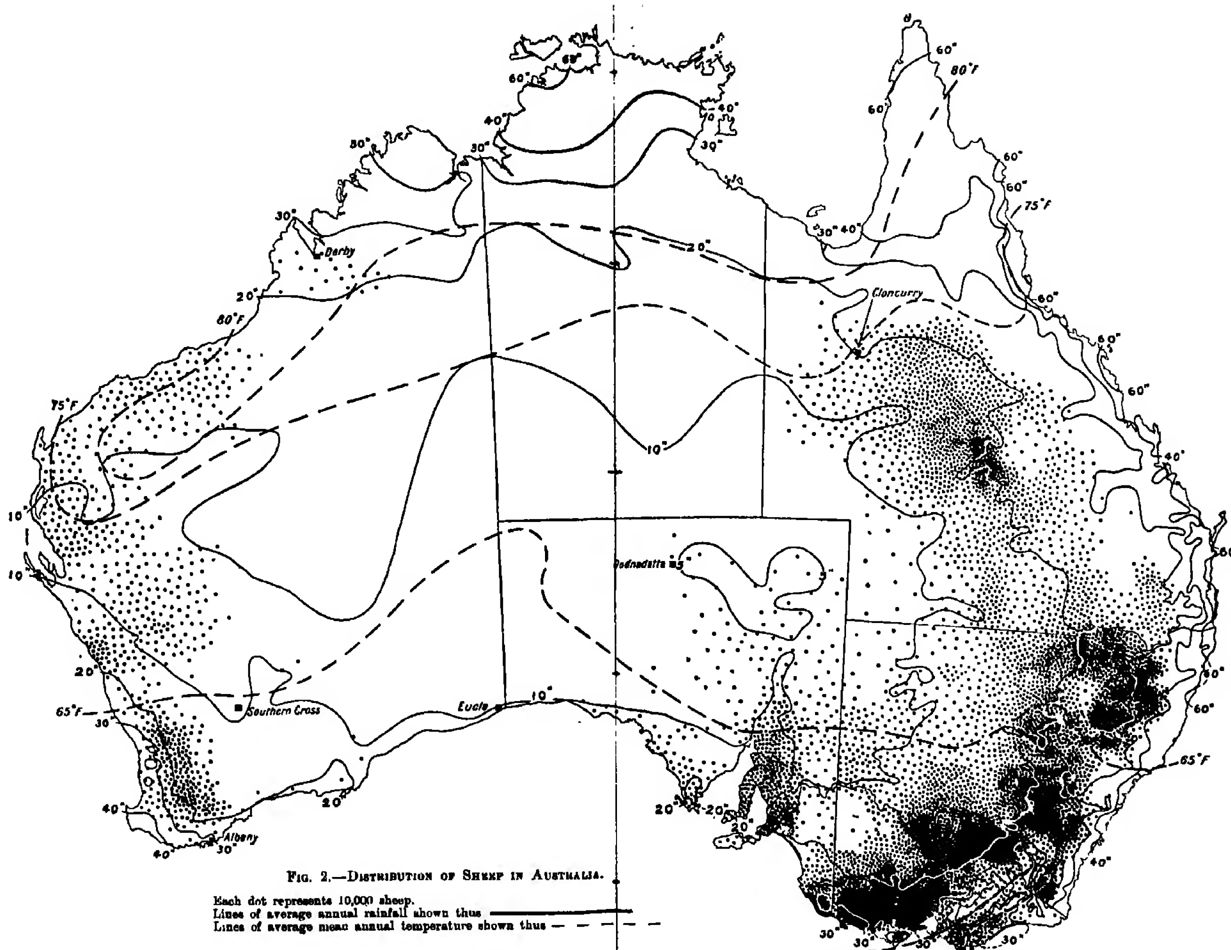

FIG. 2.—DISTRIBUTION OF SHEEP IN AUSTRALIA.

Each dot represents 10,000 sheep.
Lines of average annual rainfall shown thus
Lines of average mean annual temperature shown thus

famous sheep country of the Western District of Victoria The sheep carrying country however extends much further inland and northwards than does the wheat belt The area of maximum concentration commences in New South Wales somewhat above the 65 deg F isotherm and runs south west through that State and Victoria on either side of the 20-inch line of annual rainfall Such conditions of rainfall and temperature below 65 deg F are given suitable soil evidently the optimum conditions for sheep in Australia From this region of maximum concentration there is a wide belt of decreasing sheep concentration extending inland beyond Oodnadatta and including the South Australian sheep country The most noticeable breaks in this passage from the maximum to the minimum concentration are (1) the low concentration areas of the Victorian and South Australian Mallee where grazing to any extent is only possible after the land has been cleared and cultivated and (2) the area of higher concentration where the rainfall isohyets run northwards of the Mt Lofty Ranges It is worthy of note that along the moister eastern side of the continent there are no appreciable numbers of sheep close to the coast line not in fact until the belt of maximum cattle concentration is passed The distribution of sheep is apparently limited here by the high rainfall practically no sheep being found beyond the 40 inch line of rainfall The liability to such troubles as foot rot liver fluke and other parasitic diseases is evidently one of the factors making the keeping of sheep in such districts less profitable than cattle raising

Appreciable numbers of sheep are found as far north as Cloncurry and beyond in Queensland and around Derby in Western Australia both being about latitude 18 deg S while however in Queensland the sheep do not extend appreciably beyond the 75 deg F isotherm in Western Australia the isotherms dipping south they appear considerably above the 80 deg F isotherm The temperature range of sheep is therefore considerable as in the south eastern corner of the continent they are found in country having a mean annual temperature below 55 deg F

In Queensland the greatest concentration of sheep is about Longreach where it is to be noted there is a relatively sparse distribution of cattle Over the rest of the State inside the high rainfall coastal belt and south of the 75 deg F isotherm the distribution is fairly uniform and comparatively dense Western Australia has a small percentage of her total area as sheep

carrying country, and no region where the distribution can claim to be dense The sheep belt is along the coast, here, however, except in the extreme south-western corner, a coastal region of low rainfall

Considering the possible extension of the sheep-carrying areas This extension it may be noted, has not been very rapid over the last 20 years the numbers of sheep in Australia in 1900 and 1918 being respectively 70 602,995 and 85,194,503 or an increase of 20 per cent as compared with an increase of 33 per cent in human population There is no reason why the numbers should not be considerably increased, both by the better management of present pasture lands and the opening up of new country The areas suggesting themselves as potential sheep country are (1) the Victorian and South Australian Mallee lands, where the stocking of the country does not, as is usual, precede, but follows on after, the clearing and cultivation of the land At present few of the Mallee settlers keep sheep but with the passing of the pioneering stages of settlement, the number of small flocks kept is gradually increasing Better transport facilities, more than anything else would greatly aid the development of this section (2) There is a considerable stretch of country along the southern coast of Western Australia, bounded roughly by Southern Cross, Albany and Eucla, which is practically devoid of sheep population This is all within the 10 inch line of rainfall, and from climatic considerations above it should have a carrying capacity at least equal to the South Australian west coast, and other 10-15 inch rainfall areas Indeed, compared with South Australia, where there is the greatest development of the arid country, we might look for an extension still further inland than the area indicated Even allowing for a considerable proportion of inferior soil, there seems every reason to believe that this area is capable of supporting a population of sheep, certainly sparse, but aggregating many thousands of head (3) In Queensland, the limits of the present distribution show a fairly sharp line, both along the northern and western boundaries Allowing that the high temperature and heavy rainfall combine to make a northern extension of the sheep belt unlikely, there remains between the Queensland western boundary of the present distribution and the sheep-carrying areas of the north-west coast an immense tract of country still to be exploited The population in Queensland between the 10 and 20-inch lines of rainfall, and

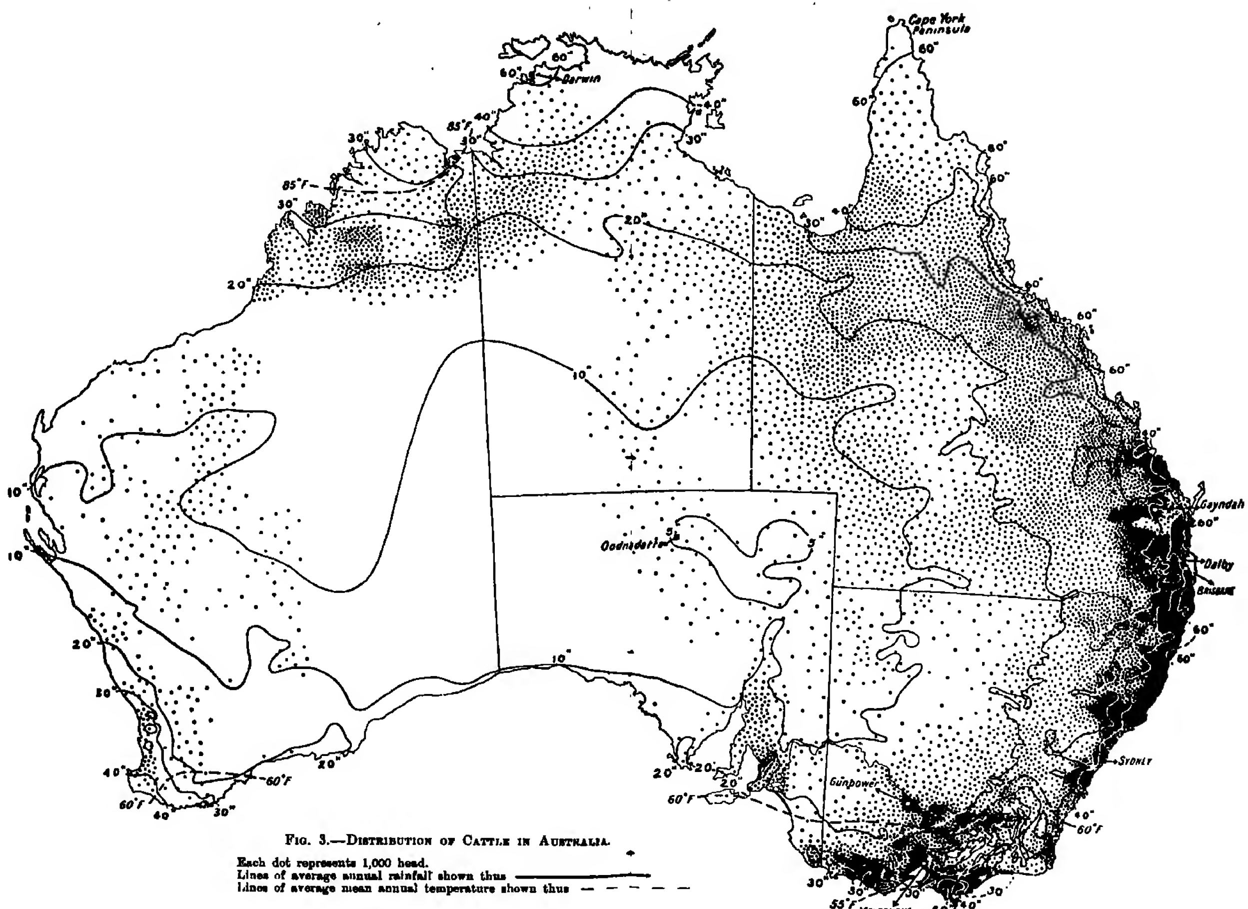

Fig. 3.—Distribution of Cattle in Australia.

Each dot represents 1,000 head.
Lines of average annual rainfall shown thus ———
Lines of average mean annual temperature shown thus — — — —

close to the 75 deg F isotherm is seen to be comparatively dense, and it can be fairly assumed that such conditions of rainfall and temperature are quite favorable to the sheep industry Between these lines of rainfall and approximating to the same temperature is a vast tract of country stretching across the Northern Territory and Western Australia Large areas of this land are doubtless of a more or less barren nature but it seems likely that with increased population and improved communication and transport facilities this area will contribute appreciably to Australia s sheep products

Cattle

There was in 1918 19 a total of 12 576 842 cattle in Australia of which number Queensland possessed 5 786 744 New South Wales 3 280 676 Victoria 1 601 544 Western Australia 943 847 the Northern Territory 621 163 and South Australia 342 768 These figures show an increase of approximately 46 per cent on the total of 8 640 225 for the year 1900 being a much more rapid increase than that shown by sheep over the same period

Examining the map of cattle distribution (Plate III) the most noticeable feature is the very general nature of such distribution cattle being found under very diverse conditions of rainfall and temperature right from Darwin and Cape York Peninsula to the southern coast The rainfall range is from 5 inches in the arid interior to over 60 inches on coastal Queensland and New South Wales and the temperature range from over 85 deg F in the far north west to below 55 deg F in the south eastern corner The ability of cattle to withstand both cold and heat, and their great travelling capacity making them invaluable in the pioneering stages of a country s development are here emphasised Compared with the distribution of sheep they not only show this wider range proving their greater adaptability to varying conditions but also the regions of maximum concentration differ markedly from those of sheep The areas of maximum concentration are found along the coasts of New South Wales and Queensland commencing just outside the sheep country and in districts having a rainfall of 40 inches and over Under such conditions cattle raising and dairying as compared with sheep are evidently so much more profitable as to practically totally exclude the latter The next greatest concentration is found in Gippsland and the Western District of

Victoria, with temperate climate and rainfall of 30 inches and upwards, but in these areas sheep also are found

The influence of the big capital cities in increasing the cattle population (for dairying and fattening purposes) is clearly shown in the comparatively poor country north of Melbourne, and to a lesser extent around Sydney and Brisbane The irrigation of the drier areas has a like effect, as shown by the relatively dense population in the county of Gunbower, Victoria, where the annual rainfall is under 15 inches The effect of varying soil fertility and topography is strikingly shown in Queensland, where between Dalby and Gayndah, within a relatively short distance, and under much the same conditions of temperature and rainfall (about the 30-inch line), we pass through a region of maximum concentration to one of very sparse distribution, and again through a maximum concentration area

What may be called the inverse distribution of sheep and cattle holds throughout, for it will be seen that in Central Queensland and New South Wales, and in Western Australia, where cattle are relatively sparsely distributed, sheep are relatively dense and vice versa

As regards the possible extension of the present boundaries of cattle distribution it is seen that the eastern half of the continent is practically totally inhabited, and development is here limited to the closer population of already inhabited areas In the western portion, however, there are vast unoccupied areas, a large proportion of which show promise of in the future carrying a considerable number of cattle Climatically, there seems no reason why the cattle population of Queensland inside the 20 inch line of rainfall should not extend across the similar belt through the Northern Territory and Western Australia The regularity of the rainfall over most of this area is quite as great as in some of the well-populated country of Queensland, with a similar annual total Artesian and sub-artesian water has helped greatly in the latter region and there seems every prospect of this being obtainable over much of the country indicated Then there is the south western portion of the continent, having a rainfall of over 10 inches, and here of great regularity, to be regarded as the potential carrier of a sparse cattle population, with the possibility of a concentration in the extreme south west corner where the rainfall is over 30 inches Here there are now, relative to the rainfall, very few cattle, the

country in its natural state being unsuited to grazing, but with the progress of agriculture there is every reason to expect a rapid increase in the numbers of cattle maintained in this well-watered region

A word as to the agricultural potentialities of Australia as indicated by this cattle distribution map It is an axiom among stockmen that "cattle country is good country", and when we consider not only the great concentration along the fertile coastal belt of the continent, but also the vast areas of New South Wales, north west Australia, and particularly Queensland, carrying relative to their human population and stage of development, a dense and uniform stock population (for it must be remembered that sheep largely fill up what appear to be the blanks in the cattle map), we can see room for a tremendous increase in Australia s population, her stock and agricultural industries, before there is need to seriously consider how we are to support her excess population in that arid interior of which we are frequently reminded Even in this arid interior we find, along the only long-established line of communication viz, the Oodnadatta railway line and telegraph line to Darwin some cattle; and it seems evident that, as our knowledge of the country and facilities for communication and transport improve, much of this country will carry stock in numbers quite sufficient to repudiate the name of desert

[Proc Roy Soc Victoria, 34 (N S), Pt II, 1922]

Art XV—*Additions to and Alterations in the Catalogue of Victorian Marine Mollusca*

By J H GATLIFF and C J GABRIEL

[Read 10th November, 1921]

Of recent years very many changes have been made in the nomenclature of the Mollusca, not only in the generic and specific names, but also in some instances a consequential alteration in the name of the family But as these changes have been adopted, more or less, by the British Museum, the United States National Museum, in the several States of this Commonwealth, and New Zealand, we have set out those which are necessary

In addition to the alterations, 43 more species have been added These include six in the Class *Cephalopoda* obtained by the ill-fated trawler *Endeavour*, and six in the *Polyplacophora*

At our request the Molluscan material collected by Mr Joseph Gabriel, in 1910, for the National Museum from the cable extending from the Victorian coast to Tasmania, which was then being raised, was submitted to us for examination at the end of last year A list of the shells thus obtained was made out and is included in the following catalogue

As indicated herein, it provides 13 additional species, that of the genus *Daphnobela* sp ? being of special interest as there is no record of its previous existence The genotype was obtained in the Eocene at Muddy Creek Victoria

We have to acknowledge the kind assistance of Mr C Hedley, Sydney, Sir Joseph Verco and Mr E Ashby, Adelaide, and Mr W L May, of Tasmania

In Vol IV, Part 5, of the Biological Results of the Commonwealth trawler *Endeavour* Professor S S Berry gives a full and excellent Report of the *Cephalopoda* obtained by that vessel, and from his work we are enabled to make the following additions to, and alterations in, the naming of our Mollusca

Class CEPHALOPODA

Order DIBRANCHIATA

Suborder DECAPODA

Family ENOPLOTEUTHIDAE

Genus **Enoploteuthis**, d Orbigny 1844

ENOPLOTEUTHIS GALAXIAS Berry

1918 *Enoploteuthis galaxis* Berry *loc cit* pp 211 221 pl 59-60

Hab—200 250 fathoms Gabo Island to region of Cape Everard Victoria

Family HISTIOTEUTHIDAE

Genus **Calliteuthis,** Verrill 1880

CALLITEUTHIS MIRANDA Berry

1918 *Calliteuthis miranda* Berry *loc cit* pp 221 228 pl 61 62

Hab—270 fathoms S E x S of Gabo Island Victoria

Family OMMASTREPHIDAE

Genus **Nototodarus,** Pfeffer 1912

NOTOTODARUS GOULDI McCoy

1897 *Ommatostrephes gouldi* McCoy Pritchard and Gatliff these Proc v X p 243

1918 *Nototodarus gouldi* McCoy Berry *loc cit* p 228 pl 63 66

Hab—60 220 fathoms Bass Strait

Family LOLIGINIDAE

Genus **Loligo,** Schneider 1784

LOLIGO ETHERIDGEI Berry

1918 *Loligo etheridgei* Berry *loc cit* pp 243 249 pl 67 68 pl 69 f 1 2

Hab—S E Australia

Family SEPIOLIDAE

Genus **Rossia,** Owen 1834

ROSSIA (AUSTROROSSIA) AUSTRALIS, Berry

1918 *Rissoa (Austrorossia) australis,* Berry *loc cit.* pp 252-258, pl 69, f 3, 4, and pl 70

Hab—200-250 fathoms, Gabo Island to Everard grounds, Victoria

Family CIRROTEUTHIDAE

Genus **Opisthoteuthis,** Verrill 1883

OPISTHOTEUTHIS PERSEPHONE Berry

1918 *Opisthoteuthis persephone,* Berry *loc cit* pp 290-293, pl 81, f 6, 7 pl 82 f 9, 10, and pl 85-88

Hab—200 fathoms 42 miles south and east of Genoa Bank, Victoria

Suborder OCTOPODA

Family POLYPODIDAE

Genus **Polypus,** Schneider 1784

POLYPUS VARIOLATUS, Blainville

? 1821 *Sepia boscii* Lesueur Jour Acad Nat Sci Philad. v II, p 101 (nomen nudum)

? 1826 *Octopus variolatus* Bl Dict Sci Nat, v XLIII, p 186

1897 *Octopus boscii,* Lesueur Pritchard and Gatliff, these Proc, v X, p 241

1918 *Polypus variolatus* Bl Berry *loc cit* p 278, pl. 79, 80, pl 81, f 2 3, and pl 82, f 1-4

Hab—Eastern slopes of Bass Strait

POLYPUS AUSTRALIS, Hoyle

1897 *Octopus australis* Hoyle Prit and Gat, these Proc, v X, p 241

1918 *Polypus australis,* Hoyle Berry *loc cit* pp 276-278 pl 78 f 1, 2, and pl 81, f 1

Hab—200 fathoms off Gabo Island

Genus **Murex**, Linne 1758

MUREX PLANILIRATUS Reeve

1898 *Murex planiliratus* Rve Prit and Gat these Proc v X p 254

1916 *Murex fimbriatus* Lk not of Solander Iredale, P Mal Soc Lond v XII p 93

1917 *Murex fimbriatus* Lk Gatliff and Gabriel these Proc v XXX p 21

Genus **Typhis**, Montfort 1810

TYPHIS PHILIPPENSIS Watson

Typhis clery Sowb not of Petit Prit and Gat, these Proc v X p 255

Genus **Lepsiella**, Iredale 1912

LEPSIELLA VINOSA Lamarck

1917 *Kalydon vinosus* Lk Gat and Gab these Proc, v XXX p 22

The following species are also transferred to this genus *Sistrum reticulatum* Quoy and G and *Trophon flindersi* Ad and Ang

Genus **Xymene**, Iredale 1915

XYMENE PAIVAE Crosse

1898 *Trophon paivae* Crosse Prit and Gat these Proc v X p 257

Genus **Neothais**, Iredale 1912

This is another genus erected for Australasian forms and will include those already listed as *Purpura succincta* Martyn, and *P baileyana* Ten Woods

Genus **Agnewia**, Tenison Woods 1878

AGNEWIA TRITONIFORMIS Blainville

1906 *Purpura tritoniformis* Bl Prit and Gat these Proc v XVIII for 1905 p 44

Genus **Drupa**, Bolten 1798

DRUPA ASPERA Lamarck

1898 *Sistrum asperum* Lk Prit and Gat these Proc, v X p 261

Genus **Charonia**, Gistel 1848.

CHARONIA RUBICUNDA, Perry

1908 *Septa rubicunda*, Perry Gat and Gab, these Proc, v XXI, p 370

Genus **Maculotriton**, Dall 1904

MACULOTRITON AUSTRALIS, Pease

1898 *Cantharus australis* Pease Prit and Gat, these Proc v X, p 274

Genus **Austrotriton**, Cossmann 1903

AUSTROTRITON PARKINSONIANA Perry

1908 *Cymatium parkinsonianum* Perry Gat and Gab, these Proc, v XXI, p 370

ARGOBUCCINUM VEXILLUM Sowerby

1835 *Ranella vexillum*, Sowb Conch Illus f 3

1908 *Argobuccinum argus* Gmelin Gat and Gab, these Proc v XXI p 369

Pritchard and Gatliff followed Tryon and others in placing *R vexillum* as a synonym but one of us has recently received a specimen of *A argus* from the South African Museum, obtained at Table Bay Cape of Good Hope, and we consider it to be a distinctly different species to our shell

Genus **Fusus**, Helbling 1779, not of Lamarck 1801

FUSUS MESTAYERAE Iredale

1898 *Pisania reticulata*, A Ad, Prit and Gat, these Proc, v X, p 274

1915 *Fusus mestayerae* Ire Trans N Z Inst, v XLVII, for 1914, p 466

This genus will also include *Colubraria bednalli* Braz

Genus Fusinus, Rafinesque 1815, replacing *Fusus*, Lamarck, not of Helbling

The following species will, therefore, be included in this genus *Fusus novaehollandiae* Rve, *F australis* Quoy and G, *F undulatus*, Perry, and *F dunkeri*, Jonas

Genus **Verconella**, Iredale 1915

VERCONELLA DILATATA, Quoy and Gaimard

1898 *Siphonalia dilatata*, Q and G Prit and Gat, these Proc, v X, p 272

VERCONELLA DILATATA, Q and G, var WAITEI, Hedley

1903 *Fusus waitei*, Hed Mem Austr Mus, v IV, p. 373 pl 37

1914 *Penion waitei*, Hed Zool Commonwealth trawler *Endeavour*, v II, p 73

1918 *Verconella waitei*, Hed J R S, N S W, v LI, for 1917, No 891, p 85

Hab—Bass Strait (*Endeavour*)

Obs—Size of type Length 150, breadth 60 mm A dull white variety

VERCONELLA MAXIMA, Tryon

1903 Siphonalia maxima, Tryon Hed Mem Austr. Mus v IV, p 374, pl 38

This figure is from a good photo of a fine specimen, 240 mm in length The species was considered by Prit and Gat to be a senile form of *S dilatata* Q and G, and it was listed accordingly We have obtained young forms which we consider confirm its specific rank

Genus **Nassarius**, Dumeril, 1806, replaces **Nassa**, Lk 1799, not of Bolten 1798

NASSARIUS SEMIGRANOSUS, Dunker

1846 *Buccinum semigranosus*, Dkr Zeits f Mal, v III, p 170

1898 *Nassa jacksoniana*, auct not of Quoy and G Prit and Gat, these Proc, v X, p 278

Until recently this shell has been cited here and in the adjacent States as *N jacksoniana*

NASSARIUS PARTICEPS, Hedley

1915 *Arcularia particeps*, Hedley P L S, N S W, v. XXXIX, p 738

1917 *Arcularia particeps*, Hed *Id*, v XLI, for 1916, p 712, pl 49, f 20

This is the species already listed in these Proceedings as *Nassa glans* of which it was considered to be a variety Under this genus will also be included all of our species hitherto listed as *Nassa*

Genus **Pterospira,** Harris 1897

PTEROSPIRA ROADKNIGHTAE McCoy

1898 *Voluta roadknightae* McCoy Prit and Gat, these Proc, v X, p 282

We have examined the type of *Voluta hannafordi,* McCoy, a fossil the genotype of *Pterospira,* Harris, and consider it to be a progenitor of *V roadknightae* We asked the opinion of Mr F Chapman Palaeontologist of the National Museum, Melbourne, as to whether he agreed with our generic classification, he decidedly coincided with us

Genus **Livonia,** Gray 1855

LIVONIA MAMILLA Gray

1908 *Voluta mamilla* Gray Gat and Gab these Proc v XXI p 371

1909 *Voluta mamilla* Gray Gat and Gab, Vic Nat, v XXVI p 117, pl 2, 3

Genus **Scaphella,** Swainson 1840

SCAPHELLA MAGNIFICA Lamarck

1804 *Voluta magnifica* Lamarck (Ch) Ann du Mus Hist Nat vol V p 156

1840 *Scaphella magnifica* Swainson Treatise Malac, pp 103-115 118 and 120

1914 *Voluta magnifica* Chemnitz (not binomial) Gat and Gab, these Proc, v XXVII, p 99

Genus **Amoria,** Gray 1855

AMORIA UNDULATA Lamarck

1898 *Voluta undulata* Lk Prit and Gat, these Proc v X, p 280

AMORIA ZEBRA Leach

1898 *Voluta zebra,* Leach Prit and Gat, these Proc v X p, 282

Genus **Ericusa**, H and A Adam 1858

ERICUSA SOWERBYI, Kiener

1839 *Voluta sowerbyi* Kr Coq Viv, p 47, pl 50
1898 *Voluta fusiformis*, Swainson Prit and Gat, these Proc, v X, p 283

ERICUSA PAPILLOSA Swainson

1898 *Voluta papillosa* Sw Prit and Gat, these Proc v X, p 282

Genus **Mitra**, Martyn, 1784

MITRA ANALOGICA Reeve var VINCTA, A Adams

1854 *Volutomitra vincta* A Ad P Z S, Lond, p 134
1874 *Mitra vincta*, A Ad Sowb Thes Con, v IV, p 25, pl 23, f 520, 521
1876 *Mitra teresiae*, Ten-Wds P R S, Tas, p 140
1901 *Turris vincta*, A Ad Tate and May, P L S, N S W v XXVI, p 361

Hab—Coast generally

Obs—Our identification was confirmed on comparison with specimens in the British Museum This variety and the following species are closely allied, but *M vincta* may be distinguished by the absence of the longitudinal ribs on the later whorls

MITRA TATEI Angas

1878 *Mitra tatei*, Ang P Z S, Lond, p 861, pl 54, f 8
1879 *Mitra weldii*, Ten Woods P R S, Tas for 1877, p 93
1899 *Turricula tasmanica*, Ten Wds Prit and Gat, these Proc, v XI, for 1898, p 188
1902 *Mitra tasmanica*, Ten-Wds var May P R S Tas, p 109, f 2

Hab—Coast generally

Obs—We have been kindly favoured by the Tasmanian Museum with the loan, for examination, of the card on which are four shells, in the form of a square, the upper one on the right is what has been decided upon as the type of *Mitra tasmanica*, the upper one on the left is the shell Tenison-Woods alludes to as variety *a* This is a very distinct species, and is figured by May,

loc cit, and is the same as that listed by Prit and Gat as *M. tasmanica* T-Wds Similar specimens have been sent to us from South Australia as *M rufocincta* A Ad, but that species is described as impressed with transverse lines between the ribs, a character lacking in the shells sent, as also in *M tatei* Tenison-Woods *loc cit* says his species is " Small banded orange and dark brown, translucent with faint ribs on upper whorls Long 10, lat 4 mm Rather common Long Bay and Blackman's Bay, and S E A" Upon examination of a very numerous series we find considerable variation, and that the ribs usually extend to the upper portion of the body whorl, also that the colour is often blackish brown bands on a white ground

Under the genus *Mitra* will also be placed the shells listed as *Turricula scalariformis,* Ten Woods, and *Turris cinnamomea,* A Adams

Genus **Marginella,** Lamarck 1799

MARGINELLA MUSTELINA, Angas

1871 *Hyalina* (*Volvarina*) *mustelina,* Ang P Z S, Lond, p 14 pl 1 f 5
1877 *Marginella stanislas* Ten Wds P R S Tas for 1876 p 133
1899 *Marginella albida* Tate Prit and Gat, these Proc v XI for 1898 p 192
1910 *Marginella stanislas* Ten-Wds Gat and Gab *Id* v XXIII p 88

Angas described the species as brown banded Ten-Woods states of *M stanislas* ' Pellucid white, or marked with four zones of variously interrupted brown spots " Tate's species, *M. albida,* is white The white variety may therefore be called *M mustelina,* Ang var *stanislas* Ten Woods and Tate's name *M albida* becomes a synonym

MARGINELLA CRATERICULA, Tate and May

1900 *Marginella cratericula,* Tate and May J R S S A, v XXIV, p 91
1901 *Marginella cratericula,* J and M P L S N S W, v XXVI, p 363, pl 26, f 74

Hab—Taken off cable to Tasmania, Bass Strait
Obs—Size of type Length 2 3, breadth 1 5 mm

MARGINELLA COLUMNARIA, Hedley and May.

Marginella columnaria, Hed. and May. Rec. Austr. Mus., p. 120, pl. 23, f. 19.

Hab.—Taken off cable to Tasmania, Bass Strait.

Obs.—Size of type: Length 7 5, breadth 3.5 mm. Shell white, sub-cylindrical, triplicate.

MARGINELLA PULCHELLA, Kiener.

1830. *Marginella pulchella,* Kr. Coq. Viv., p. 27, pl. 9, f. 41 (not 40, as in text).

1911. *Marginella fulgurata,* Hed. Zool. Commonwealth trawler *Endeavour,* v. I., p. 110, pl. 7, fig. 31 only.

Hab.—Portland.

Obs.—This species has many axial undulating lines; these are thickened centrally, and near to each end, giving the appearance of encircling bands.

We also have the species from N.S. Wales, South Austr., and West Austr., and it has been sent to us from those States with the name of *M. sagittata,* Hinds, which species it resembles; we have the latter from Bahama Isls.

MARGINELLA GEMINATA, Hedley.

1903. *Marginella laevigata,* Hed., not of Braz. Mem. Aust. Mus., v. IV., p. 364, f. 89.

1912. *Marginella geminata,* Hed. Rec. Aust. Mus., v. VIII, p. 145, pl. 42, f. 28.

Hab.—Dredged in 7-8 fathoms, Western Port.

Obs—Mr. Hedley states he mistakenly figured another shell as being *M. laevigata,* and later he described it as *M. geminata.* The earlier figure represents the shell we find, the later figure is probably drawn from an immature specimen. Mr. Hedley kindly sent us for examination and return co-types of the two species; they are very similar.

Family PYRENIDAE, replaces Columbellidae.

This change is necessary owing to *Pyrene,* Bolten 1798, being prior to *Columbella,* Lamarck 1799. *Pyrene* being a montypical genus represented by *P. rhombiferum,* Bolt., a new name he gave to *Buccinum punctatum,* Bruguiere 1789, and to the figure of

which species he referred, we only adopt his generic name as applicable to similar forms *Columbella mercatoria* being recognised as the type of Lamarck's genus, there being no forms similar to these two in our waters, and as it has been decided to split up the great assemblage of species hitherto classed as *Columbellidae,* we have adopted the following generic names for our species

Genus **Mitrella,** Risso 1826

MITRELLA SACCHARATA, Reeve

1859 *Columbella saccharata,* Rve Conch Icon, pl 29, f 187

1901 *Columbella (Mitrella) saccharata,* Rve Tate and May, P L S, N S W, v XXVI, p 366

Hab—Dredged Western Port, taken off cable to Tasmania, Bass Strait

Obs—Its nearest congener is *C semiconvexa,* Lk, from which it may be distinguished by its narrower form and smaller size, the type is in the British Museum, locality, "Van Diemen's Land"

Others listed as *Columbella* now included in *Mitrella* are *C semiconvexa* Lk, *C austrina* Gask, *C menkeana,* Rve, *C lincolnensis,* Rve, *C angasi,* Braz, *C tenisoni* Tryon, *C tenuis,* Gask., *C tenebrica,* Rve, *C nubeculata,* Rve, *C beddomei,* Petterd, *C legrandi,* Ten-Wds, *C lurida,* Hed, and *C franklinensis,* Gat and Gab

Genus **Aesopus,** Gould 1860

AESOPUS CASSANDRA, Hedley

1909. *Daphnella cassandra,* Hed Gat and Gab, these Proc, v XXIX, p 37

1918. *Aesopus cassandra,* Hed Jour R S, N S W, v LI. for 1917, p 90, No 948a

AESOPUS PALLIDULUS Hedley

1907 *Mitromorpha pallidula,* Hed Gat, these Proc, v XX, p 32

1918 *Aesopus pallidulus,* Hed *Id* No 948b

We follow Mr Hedley in his transference to this genus of the two foregoing species And also transfer to it *Columbella plurisulcata,* Rve, previously listed by us

The species listed as *Manguia gatliffi*, Verco, will also be included in the genus *Aesopus*

Genus **Zafra**, A Adams 1860

This contains the small axially plicate species, which we have already listed as *Columbella atkinsoni*, Ten-Wds, *C smithi*, Ang, *C cominellaeformis*, Tate, and *C remoensis*, Gat and Gab The last named species is not a typical form, but at present we place it in this genus

Genus **Retizafra**, Hedley 1918

RETIZAFRA CALVA, Verco

1911 *Columbella calva*, Verco Gat and Gab, these Proc, v XXIV, p 194

1913 *Retizafra calva*, Verco Hed, P L S, N S W, v XXXVIII, p 326

This genus comprises small forms with clathrate sculpture, and includes *Columbella gemmulifera*, Hed, already listed

Genus **Conorbis**, Swainson 1840

CONORBIS SARCINULA Hedley

1905 *Bathytoma sarcinula*, Hed Rec Austr Mus, v VI, p 53, f 21

1918 *Apaturris sarcinula*, Hed Jour R S N S W v LI, for 1917, p 80, No 831

Hab—Taken off cable to Tasmania, Bass Strait

Obs—Size of type Length 7, breadth 4 mm

Mr Hedley's excellent description and figure of the species, readily enabled the identification of our shell, his single specimen was dredged in 111 fathoms 12½ miles due east of Cape Byron Mr Hedley and one of us compared the single specimen got off the cable with the type, they were absolutely the same in size, colour and sculpture, and both fresh shells We do not agree in the classing of it in either of the genera named, and place it in the genus *Conorbis*

Family TURRIDAE, replaces Pleurotomidae

Genus **Hemipleurotoma**, Cossmann 1889

This includes the shell listed as *Drillia quoyi*, Desmoulins

Genus **Glyphostoma**, Gabb 1872

GLYPHOSTOMA WALCOTAE Sowerby

1893 *Drillia walcotae* Sowb P Z S Lond p 487 pl 38 f 7 8

1909 *Clathurella walcotae* Sowb Verco T R S S A v XXXIII p 307

Hab—*Portland*

Obs—This is the largest of the species of this genus found in our waters and may be recognised by its broad and robust form The size of our shell is Length 15 breadth 8 mm

GLYPHOSTOMA NASSOIDES Reeve

1845 *Pleurotoma nassoides* Rve Conch Icon v I, pl 29 f 259

1884 *Clathurella nassoides* Rve Tryon Man Conch v VI p 296 pl 15 f 29

1900 *Clathurella zonulata* Ang Prit and Gat these Proc v XII p 178

Under the genus *Glyphostoma* will also be included the species listed as *Clathurella bicolor* Ang *C denseplicata* Dkr and *C kymatoessa* Watson

Genus **Macteola** Hedley 1918

This includes the species listed as *Mangilia anomala* Ang, and it is selected by Hedley as his genotype

Genus **Daphnella**, Hinds 1844

DAPHNELLA CREBRIPLICATA Reeve

1846 *Pleurotoma crebriplicata* Rve P Z S Lond p 3

1846 *Pleurotoma crebriplicata* Rve Conch Icon v I, pl 34 f 313

1906 *Daphnella fragilis* Rve Prit and Gat these Proc v XVIII p 51

Genus **Syntagma**, Iredale 1918

This includes the species listed as *Donovania fenestrata* Tate and May

Genus **Exomilus**, Hedley 1913

This includes the species listed as *Drillia telescopialis* Verco, and *Mangilia hilum* Hed

Genus **Mitromorpha**, A Adams 1865

MITROMORPHA INCERTA, Pritchard and Gatliff

1906 *Mangilia* (?) *incerta*, Prit and Gat, these Proc, v XVIII, p 50

Genus **Nepotilla**, Hedley 1918

This includes the species listed as *Daphnella excavata*, Gatliff, and *D microscopica*, May

Genus **Taranis**, Jeffreys 1870

This includes the species listed as *Daphnella lamellosa*, Sowb, *D triseriata*, Verco, and *D mayi Verco*

Genus **Pseudodaphnella**, Boettger 1895

This includes the species listed as *Clathurella tincta*, Rve, *C modesta*, Ang, *C sexdentata*, Prit and Gat, *C albocincta*, Ang, *C legrandi* Bedd and *Daphnella bitorquata*, Sowb

Genus **Daphnobela**, Cossmann 1896

DAPHNOBELA sp ?

A single specimen was obtained off the cable to Tasmania, Bass Strait, it has not yet been described or figured

Genus **Cypraea**, Linnaeus 1758

CYPRAEA ALBA, Cox

1879 *Cypraea umbilicata*, Sowb var alba, Cox P L S, N S W v IV, p 386

1885 *Cypraea umbilicata*, Sowb var alba Cox Tryon, Man Conch, v VII, p 181

1888 *Cypraea umbilicata* Sowb var alba, Cox Melvill, Proc Manchester, Lit and Phil Soc, p 58

1907 *Cypraea umbilicata* Sowb var alba, Cox Hidalgo, Monog Viv Cypraea, pp 548 and 579

Hab—Bass Strait

CYPRAEA ALBA, Cox, var HESITATA, Iredale

1900 *Cypraea umbilicata*, Sowb Prit and Gat, these Proc, v XII, for 1899, p 187

1912 *Cypraea umbilicata*, Sowb Verco, T R S, S A, v XXXVI, p 211

1916 *Cypraea hesitata*, Ire P Mal Soc Lond, v XII, p 93

1918 *Cypraea armenaiaca*, Hed, not of Verco J R S, N S W, v LI, for 1917, p 70, No 709

Mr Iredale *loc cit* proves that the name of *C umbilicata* is pre-occupied by Dillwyn As a new name had to be found for *C umbilicata*, Sowb, the varietal name alba, Cox, P L S, N S W, vol IV, 1879, is entitled to become the species name, and that of *C hesitata* may be substituted as a varietal name

Sir Joseph Verco *loc cit* fully gave the history of this species, and also named, what he thought might be a variety only, a shell with apricot colouration, as *Cypraca umbilicata*, Sowb, var *armeniaca* The description is full, and the figure excellent Upon comparison with Tasmanian forms of *C umbilicata*, Sowb he remarks "Mine differs in shape being more globular, higher, and wider, not only relatively, but absolutely We will hope other specimens may be secured which will determine its right to be called a good species"

Of the specimens we have seen, including those in the Australian Museum, Sydney, none could be regarded as intergrading with *C umbilicata* Sowb, of which we have specimens from Tasmania, also dredged off Cape Everard (living), and Lakes Entrance, Victoria, and we have seen many others

We therefore establish *Cypraea armeniaca* Verco, as a species

Genus **Natica**, Scopoli 1777

NATICA SCHOUTANICA, May

1912 *Natica schoutanica* May P R S, Tas, p 45, pl 2, f 3

Hab—Taken off cable to Tasmania, Bass Strait

Obs—Size of type "Diameter, major 5 5, minor 4 5, height 5 mm" "Yellowish white, irregularly netted with broken zigzag lines of chestnut"

Genus **Polinices**, Montfort 1810

This comprises species listed as *Natica plumbea*, Lk, *N. didyma*, Ch *N conica*, Lk, *N incei*, Phil, and *N beddomei*, Johnston

Genus **Sinum**, Bolten 1798, replaces *Sigaretus*, Lamarck 1799

Genus **Marsenlopsis**, Bergh, replaces *Lamellaria*, Montagu

Genus **Merria,** Gray 1839 replaces *Vanikoro,* Quoy and Gaimard

Genus **Siliquaria,** Bruguiere 1789 replaces *Tenagodes* Guettard

Genus **Architectonica,** Bolten 1798 replaces *Solarium* Lamarck 1799

Genus **Naricava,** Hedley 1913

The species of *Adeorbis* we have listed have been transferred to the above genus they are *A vincentiana* Ang *A angasi A Adams* and *A kimberi* Verco

Genus **Epitonium,** Bolten 1798 replaces *Scala,* Klein 1753 (pre Linn)

EPITONIUM ACULEATUM Sowerby

1844 *Scalaria aculeata* Sowb Thes Conch v I p 86 pl 32 bis f 35 36

1901 *Scalaria aculeata* Sowb Tate and May P L S N S W v XXVI p 379

1906 *Scala aculeata* Sowb Verco T R S S A v XXX p 143

Hab —Dredged in 6 8 fathoms living off Phillip Isl Western Port

We have dredged specimens 32 mm in length by 11 mm in breadth

This genus will also include *S jukesiana* Forbes *S australis* Lk *S granosa* Q and G *S tenella* Hutt *S morchi* Ang , *S acanthopleura* Verco and *S platypleura* Verco

Genus **Phalium,** Rostock 1807

PHALIUM SINUOSUM Verco

1904 *Cassidea sinuosa* Verco T R S S A v XXVIII, p 141 pl 26 f 7 10

Hab —Taken off cable to Tasmania Bass Strait

Obs —Size of type Length 24 breadth 15 mm differs from its nearest relative *C adcocki* in not having nodules on the last whorl and the labrum is not thickened but sinuous

Under the genus *Phalium* are included the shells listed as *Cassis pyrum* Lk *C achatina* Lk *C semigranosa* Lk *C adcocki* Sowb and *C achatina* Lk var *stadialis* Hed

Family STROMBIFORMIDAE, replaces Eulimidae

Genus **Melanella**, Bowditch 1822, replaces *Eulima*, Risso 1826

This includes species already listed as *Eulima indiscreta*, Tate, *E commensalis*, Tate, *E augur*, Ang, *E. inflata*, Tate and May, *E tryoni*, Tate and May, *E immaculata*, Prit and Gat, *E tenisoni*, Tryon, *E orthopleura*, Tate, and *E victoriae*, Gat and Gab

Genus **Mucronalia**, A Adams 1862

This includes our species listed as *Eulima mucronata*, Sowb, and *E coxi*, Pilsbry

Genus **Strombiformis**, Da Costa 1778

This includes our species listed as *Leiostraca acutissima* Sowb, *L lodderae*, Hed, *L kilcundae* Gat and Gab *L styliformis*, Gat and Gab, *L joshuana* Gat and Gab *Rissoa perexigua*, Tate and May, *Eulima topaziaca* Hed and *E marginata*, Ten-Woods

Genus **Syrnola**, A Adams 1860

This includes our species listed as *Pyramidella bifasciata*, Ten-Wds, *P tincta*, Ang, and *P jonesiana*, Tate

Genus **Leucotina**, A Adams 1860

This includes our species listed as *Turbonilla* (*Ondina*) *micra*, Prit and Gat, *T* (*Ondina*) *casta* A Ad, and *T* (*Ondina*) *harrissoni* Tate and May

Genus **Cingulina**, A Adams 1860

CINGULINA SPINA, Crosse and Fischer

Now classed as *Cingulina* instead of *Turbonilla spina*, as formerly listed

Genus **Oscilla**, A Adams 1867

OSCILLA TASMANICA, Tenison Woods

1906 *Oscilla ligata*, Ang Prit and Gat, these Proc, v XVIII, for 1905 p 59

Both these names were published in the same year, it has now been ascertained that T Wds has priority Angas was the first to figure it *O ligata*, Ang, becomes a synonym

Genus **Cerithiopsis,** Forbes and Hanley 1853

CERITHIOPSIS CESSICUS, Hedley

1906 *Bittium minimum,* Ten-Woods Prit and Gat, these Proc, v XVIII, for 1905, p 59, not of Brusina, 1864

1906 *Cerithiopsis cessicus* Hed P L S, N S W, v XXX p 529

Genus **Batillaria,** Benson 1842

This includes our shell listed as *Potamides australis,* Quoy and Gaim

Genus **Diala,** A Adams 1861

DIALA SEMISTRIATA Philippi

The shell previously listed as *Diala varia* A Adams, becomes a synonym as it had already been named as above (fide Melvill and Standen, also Suter)

Genus **Melarhaphe,** Menke 1828

MELARHAPHE UNIFASCIATA Gray

1827 *Littorina unifasciata* Gray King's Survey of Australia v II App p 483

1902 *Littorina mauritiana* Lk Prit and Gat, these Proc v XIV for 1901 p 90

Our shell is very similar to *mauritiana* Lk and the brief original description of it, as far as it goes, covers both species, but the clear and ample description by Gray enables their separation, *unifasciata* is found all round the coast of Australia, Tasmania also in New Zealand

Included in the genus is the species listed as *Littorina novae zealandiae* Rve

Genus **Liotia,** Gray 1842 (*Pseudoliotia* Tate 1898 is a synonym)

Our shell listed as *Pseudoliotia micans* A Ad, is now called a *Liotia*

Genus **Liotina,** Fischer 1885

The shells previously listed as *Liotia australis* Kr, *L subquadrata,* Ten-Woods *L tasmanica,* Ten-Wds, *L hedleyi,* Prit and Gat, and *L mayana,* Tate, are now classed as *Liotina*

Genus **Liotella**, Iredale 1915

In this genus are included *Liotia annulata*, Ten-Woods, and *Liotia petalifera* Hed and May

Genus **Cyclostrema**, Marryat 1818

This genus has been greatly split up, and some new genera erected We class ours already listed as follow —

Genus **Elachorbis**, Iredale 1915

This includes the shells already listed as *Cyclostrema caperatum* Tate, *C delectabile* Tate *C inscriptum* Tate, *C harrietiae*, Petterd and *C homalon*, Verco

Genus **Brookula**, Iredale 1912

This includes the shells listed as *Cyclostrema angeli*, Ten-Wds *C johnstoni*, Beddome, *C denseplicata* Verco, and *Scala* nepeanensis Gatliff

Genus **Cirsonella**, Angas 1877

This includes the shells listed as *Cyclostrema weldii*, Ten-Wds, and *C microscopica* Gat and Gab

Genus **Lissotesta**, Iredale 1915

This includes the shells listed as *Cyclostrema micra* Ten-Wds (Iredale's genotype), *C porcellana*, Tate and May, and *C contabulatum* Tate var

Genus **Orbitestella**, Iredale 1917

This includes the shells listed as *Cyclostrema bastowi* Gatliff (Iredale's genotype), and *C mayi* Tate

Genus **Microdiscula**, Thiele 1912

This includes the shell listed as *Cyclostrema charopa*, Tate

Genus **Skenella**, Pfeffer 1886

SKENELLA BRUNNIENSIS, Beddome

1902 *Cyclostrema bruniensis* Bedd Prit and Gat, these Proc, v XIV, for 1901, p 99

The genus *Rissoa*, Fréminville, 1814, has also been greatly split up, we class ours already listed as follow —

Genus **Haurakia**, Iredale 1915

This includes the following species —

HAURAKIA DESCREPANS, Tate and May

1900 *Rissoa descrepans*, Tate and May T R S, S A, v XXIV, p 99

1901 *Rissoa descrepans*, Tate and May P L S, N S W, vol XXVI p 391 pl 26, f 65

1909 *Rissoa incompleta* Hed Gat and Gab, these Proc, v XXII, p 41

1918 *Haurakia descrepans*, Tate and May Hed, Jour R S, N S W, v LI, for 1917, p 51 No 498

R liddeliana, Hed, is also included in the genus *Haurakia*

Genus **Merelina**, Iredale 1915

This includes the shells listed as *Rissoa cheilostoma* Ten-Wds (Iredale's genotype), *R strangei* Braz *R hulliana* Tate, *R gracilis*, Ang, *R australiae*, Frauenf, *R agnewi*, Ten-Wds, and *R filocincta* Hed and May

Genus **Lironoba**, Iredale 1915

This includes shells listed as *Rissoa tenisoni* Tate, *R imbrex*, Hed *R schoutanica* May, *R iravadioides*, Gat and Gab, and *R wilsonensis*, Gat and Gab

Genus **Estea**, Iredale 1915

This includes the shells listed as *Rissoa subfusca* Hutt (Iredale's genotype), *R incidata* Frauenf, *R janjucensis*, Gat and Gab, *R frenchiensis* Gat and Gab, *R woodsi* Prit and Gat, *R flammea* Frauenf *R pyramidata* Hed, *R rubicunda*, Tate and May, *R dubatabilis* Tate, *R bicolor*, Petterd, *R erratica*, May, *R salebrosa*, Frauenf, *R columnaria* Hed and May, *R olivacea*, Dunker, *R aurantiocincta*, May, *R obeliscus*, May; also—

ESTEA TUMIDA, Tenison-Woods

1876 *Diala tumida*, Ten-Wds, P R S, Tas, p 147

1919 *Estea tumida*, Ten-Wds May, *Id*, p 60, pl 15, f 9

Hab—Western Port

Obs—Size of type Length 2 50, breadth 1 mm

ESTEA KERSHAWI Tenison-Woods

1877 *Rissoina kershawi*, Ten -Wds , these Proc , v XIV , p 57

1919 *Estea kershawi*, Ten -Wds May, P R S , Tas , p 60, pl 15, f 11

Hab —Dredged in about 8 fathoms, off Rhyll, Western Port

Obs —Size of type Length 3, breadth 1 33 mm

ESTEA MICROCOSTA May

1919 *Estea microcosta*, May P R S , Tas , p 61, pl 15 f 12

Hab —Off Wilson s Promontory

Obs —Identification endorsed by the author, who remarks "This is closely related to *E kershawi* It differs principally in the much more numerous and fine ribs, and rounder mouth and its rather more cylindrical form" Size of type Length 2 5, breadth 1 2 mm

Genus **Amphithalamus**, Carpenter 1863

This includes our shells listed as *Rissoa approxima*, Petterd, *R jacksoni* Braz , and *R petterdi*, Braz

Genus **Anabathron**, Frauenfeld 1867

This includes the species listed as *Rissoa contabulata*, Frauenf

Genus **Epigrus**, Hedley 1903

This includes our shells listed as *Rissoa verconis*, Tate, *R verconis* Tate, var *apiculata* Gat and Gab , *R dissimilis*, Watson

Genus **Notosetia**, Iredale 1915

This includes our shells listed as *Rissoa atropurpurea*, Dkr , *R atkinsoni*, Ten -Wds , *R nitens* Dkr , *R simillima*, May, *R pellucida* Tate and May, *R pertranslucida*, May, and *R melanochroma*, Tate

Genus **Subonoba**, Iredale 1915

This includes our shell listed as *Rissoa bassiana*, Hed

Genus **Rissopsis**, Garrett 1873

RISSOPSIS BREVIS May

1919 *Rissopsis brevis* May P R S Tas p 63 pl 16 f 19

Hab—Bass Strait

Obs—Size of type Length 2 breadth 8 mm a very small white shell

Genus **Rissoina**, d Orbigny 1840

RISSOINA LINTEA Hedley and May

1908 *Rissoina lintea* Hed and May Rec Aust Mus v VII p 17 pl 22 f 9

Hab—Taken off cable to Tasmania Bass Strait

Obs—Size of type Length 7 breadth 2 5 mm

Genus **Rissolina**, Gould 1861

RISSOLINA ANGASI Pease

This spec es was listed as a synonym of *Rissoina flexuosa* Gould owing to its wrongful identification by Prof Tate *R flexuosa* is not a *Rissolina* and according to Mr Hedley is a synonym of *Rissoina fasciata* Adams *R crassa* Ang is also included in the above genus

Genus **Phasianella**, Lamarck 1804

PHASIANELLA PERDIX Wood

1914 *Phasianella perdix* Wood Gat and Gab Vic Nat v XXXI p 82

Genus **Gabrielona** Iredale 1917

GABRIELONA NEPEANENSIS Gatliff and Gabriel

1908 *Phasianella nepeanensis* Gat and Gab these Proc v XXI pp 366 and 379 pl 21 f 9 10

Iredale has selected this species as the genotype

Genus **Astraea**, Bolten 1798 replaces *Astralium* Link 1807

ASTRAEA FIMBRIATA Lamarck

1822 *Trochus fimbriatus* Lk Anim S Vert v VII, p 12

1902 *Astralium squamiferum* Koch Prit and Gat, these Proc v XIV for 1901 p 117

The forms described under the two above names have been considered by some to be varying forms of one species, ours is that described by Lamarck

Genus **Cantharidus,** Montfort 1810 (*Phasianotrochus,* Fischer 1885 is a synonym)

CANTHARIDUS EXIMIUS Perry

This name replaces that listed as *Phasianotrochus carinatus,* Perry, who called it a *Bulimus* and the name *B carinatus* had been previously used by Bruguiere

CANTHARIDUS NITIDULUS Philippi

1849 *Trochus nitidulus,* Phil Conch Cab, p 295, No 383, pl 43, f 10

Hab—Portland, and off cable to Tasmania, Bass Strait

Genus **Calliostoma,** Swainson 1840

CALLIOSTOMA ARMILLATUM, Wood

1828 *Trochus armillatus* Wood Index Test Supplement pl 5, f 5

1901 *Calliostoma meyeri,* Phil Prit and Gat, these Proc v XIV p 134

Wood's name was not previously adopted, because there was no description of the shell The rules of the International Congress now allow a binomial name accompanied by a figure to be sufficient

CALLIOSTOMA COMPTUM A Adams

1913 *Calliostoma comptum,* A Ad Hed P L S, N S W, v XXXVIII, p 279

This species was listed as *C poupineli* Montr, from New Caledonia Upon consulting the original description of that species we find that it is distinct from ours

Genus **Cantharidella,** Pilsbry 1889

This genus includes the shell listed as *Gibbula tiberiana,* Crosse

Genus **Calliotrochus,** Fischer 1880

This includes the shells listed as *Gibbula tasmanica,* Petterd, *and G legrandi,* Petterd

Genus **Haliotis,** Linnaeus 1758

HALIOTIS ROEI, Gray

1826 *Haliotis roei,* Gray King's Survey of Australia, pp 157 and 493

1846 *Haliotis roei,* Gray Rve, Conch Icon, v III, pl 4, f 10

1859 *Haliotis roei,* Gray Chenu, Man Conch, v I, p 367, f 2739 and 2740

Hab—Portland

Genus **Megatebennus,** Pilsbry 1890

MEGATEBENNUS JAVANICENSIS, Lamarck

1914 *Megatebennus javanicensis,* Lk Gat and Gab, Vic Nat, v XXXI, p 82

Genus **Diodora,** Gray 1821, replaces *Fissuridea* Swainson 1840

Genus **Montfortula,** Iredale 1915

This includes the species listed as *Subemarginula emarginata,* Bl and *S rugosa* Quoy and Gaim

Genus **Scutus,** Montfort 1810

SCUTUS ANTIPODES, Montfort

1810 *Scutus antipodes* Montf Conch, Syst, v II, p 58 pl 15

1902 *Scutus anatinus* Donovan Prit and Gat, these Proc, v XV, p 188

1917 *Scutus antipodes,* Montf Hed P L S, N S W, v XLI, for 1916, p 704, pl 47, f 7-9

Genus **Tugalia,** Gray 1843

TUGALIA CICATRICOSA, A Adams

1852 *Tugali cicatricosa,* A Ad P Z S, Lond for 1851, p 89

1863 *Tugalia cicatrosa,* A Ad Sowb, Thes Con, v III, p 222, pl 14, f 14

1865 *Tugalia cicatricosa,* A Ad P Z S, Lond, p 185

1870 *Tugalia cicatrosa,* A Ad, Rve Conch Icon, v XVII, pl 1, f 7

1890 *Tugalia cicatricosa*, A Ad Tryon, Man Conch, v XII, p 285, f 86, *not* 85

1917 *Tugalia cicatricosa*, A Ad Hed, P L S, N S W, v XLI, p 698, for 1916

Hab—Dredged with the animal, Half Moon Bay, Port Phillip, also Western Port

Obs—Tryon's fig 86 *loc cit* is a copy of that in Thes Conch, and is referred to in the text and table of the plate as 86, but on the plate is wrongly numbered 85, and that of *T carinata* 86, evidently a reversal, in error Hedley's fig 26, plate 52 *loc cit* does not represent the species He states "A scar on the summit, which suggested the name, was an individual and accidental feature of the type shell It is by chance repeated in a specimen before me and was probably caused by adherence of a *Capulus*, or some such associate"

We have obtained over 20 specimens some of them dredged with the animal all with the summit free from any encumbrance, and we also have similar specimens from South Australia, and cannot agree with Hedley's surmise

The habitat of the type is given as Philippine Islands, it is more coarsely sculptured than as we find it

Genus **Cellana**, H Adams 1869, replaces *Helcioniscus*, Dall 1871

CELLANA VARIEGATA, Blainville

1825 *Patella variegata*, Bl Dict Sci Nat, v. XXXVIII, p 100

1908 *Helcioniscus diemenensis*, Phil Gat and Gab, these Proc, v XXI, p 382

1915 *Helcioniscus variegatus*, Bl Hed, P L S, N S W, v XXXIX, for 1914, p 714

Genus **Patella**, Linnaeus 1758

PATELLA VICTORIAE, Gatliff and Gabriel, nom mut

1902 *Patella hepatica*, Prit and Gat, not of Gmelin, these Proc, v XV, p 194

PATELLA SQUAMIFERA, Reeve

1902 *Patella aculeata*, Rve, not of Gmelin, Prit and Gat *Id*, p 193

Genus **Nacella**, Schumacher 1817

NACELLA PARVA Angas

1878 *Nacella parva* Ang P Z S Lond p 862 pl 54, f 12

1912 *Nacella parva* Ang Verco T R S S A v XXXVI p 183

Hab—Portland

Obs—Found living on the seaweed *Cymodocea antarctica* associated with *Nacella stowae* Verco and *Stenochiton cymodocealis* Ashby A rather constant feature is A single row of pale blue spots and crescent shaped opaque markings extending from the apex centrally more or less along the outer arc of the shell Size of type Diam maj 6 min 3 alt 2mm

Genus **Patelloida** Quoy and Gaim 1834 replaces (*Acmae* Eschscholtz 1828 not of Hartman 1821

Genus **Callochiton**, Gray 1847

CALLOCHITON MAYI Torr

1912 *Callochiton mayi* Torr P R S Tas p 1

1912 *Callochiton mayi* Torr May and Torr *Id* p 28 pl 1 f 5 7

1912 *Callochiton mayi* Torr T R S S A v XXXVI p 164 pl 5 f 1a f

Hab—Portland

Obs—Size of type Length 15 breadth 8 mm A beautifully ornate little species The girdle with its dense microscopic diamond shaped scales longitudinally sulcate pleural areas and dots on the lateral areas serve as useful recognition marks

CALLOCHITON RUFUS Ashby

1900 *Callochiton rufus* Ashby T R S S A p 87 pl 1 f 2a g

1921 *Callochiton rufus* Ashby these Proc v XXXIII, for 1920 p 150

Hab—Port Phillip Heads (J B Wilson)

Obs—Size of type Length 16 breadth 10 mm Ashby *loc cit* says this was misidentified by Sykes as *C platessa* Gould

Genus **Stenochiton,** Adams and Angas 1864

STENOCHITON CYMODOCIALIS Ashby

1918 *Stenochiton cymodocealis* Ashby T R S S A v XLII p 70 pl 13 14 f 1 4 5 11 12

Hab—Portland

Obs—Size of type Length 10 breadth 3 5 mm found on the seaweed *Cymodocea antarctica*

Genus **Ischnochiton,** Gray 1847

ISCHNOCHITON DECUSSATUS Reeve

1847 *Chiton decussatus* Rve Conch Icon sp 107 pl 18 f 107 also pl of Details of sculpture f 107

Hab—Portland

Obs—Dr Torr has erroneously placed this species as a synonym of *Chiton sulcatus* Q and G They differ distinctly Quoy and Gaimard s name is not available as in 1815 in General Conchology p 16 pl 3 f 1 Wood described and figured a different shell under that name and it is quoted by Dillwyn in his Cat Recent Shells p 8

ISCHNOCHITON IREDALEI Dupuis

1917 *Ischnochiton lineolatu* Iredale and May not of Blainville Gat and Gab these Proc v XXX p 26

1918 *Ischnochiton iredalei* Dup Bull Mus Hist Nat No 7

1921 *Ischnochiton iredalei* Dup Ashby these Proc v XXXIII for 1920 p 151

1921 *Ischnochiton iredalei* Dup Ashby T R S S A v XLIV for 1920 p 284

Obs—This is *I contractus* auct not of Reeve

Genus **Plaxiphora,** Gray 1847

PLAXIPHORA BEDNALLI Thiele

1909 *Plaxiphora glauca* Quoy and Gaim Gat and Gab these Proc v XXII p 42

1909 *Plaxiphora bednalli* Thiele Revision des Systems des Chitonen p 25, pl 3, f 27-31

Obs—This species was identified by Bednall as *P glauca*, Q and G, and he sent a specimen to Thiele, who said it was not that species, and named it *P bednalli*

PLAXIPHORA COSTATA, Blainville

1825 *Chiton costata*, Bl Dict Sci Nat, vol XXXVI, p 548

1893 *Chiton costatus*, Bl Pilsbry, Man Conch, v XV, p 105

1902 *Plaxiphora petholata*, Sowerby Prit and Gat, these Proc, v XV, p 204

Genus **Acanthochitona,** Gray 1821 replaces *Acanthochites*, Risso 1826

ACANTHOCHITONA COSTATA Adams and Angas

1864 *Acanthochites costatus*, Ad and Ang P Z S, Lond, p 194

1893 *Acanthochites costatus* Ad and Ang Pilsbry, Man Conch, v XV, p 40, pl 3, f 74

Hab—Portland

Obs—Size of type Length 18 breadth 7 mm This was obtained in New South Wales, it is also recorded in Queensland, South Australia, and Tasmania

ACANTHOCHITONA GATLIFFI, Ashby

1919 *Acanthochiton gatliffi* Ashby T R S, S A, v XLIII, p 398, pl 42 f 2 5

1921 *Acanthochiton gatliffi* Ashby These Proc, v XXXIII for 1920, p 152

Hab—Dredged off Point Cook, Port Phillip, in 8 fathoms

Obs—Size Length 6, breadth 3 mm

ACANTHOCHITONA TATEI, Torr and Ashby

This proves to be a synonym of *A granostriatus* Pilsbry

Genus **Rhyssoplax,** Thiele 1893

Under this new genus are now classed the species listed as *Chiton bednalli*, Pilsbry, *C tricostalis*, Pilsbry, *C jugosus*, Gould, *C exoptanda*, Bednall, *C verconis*, Torr and Ashby, and *C calliozona*, Pilsbry

CHITON LIMANS, Sykes

This name drops, and must be deleted from our list It had been revived by Sykes but as Ashby has pointed out in his report on the Bracebridge Wilson collection of Chitons in the National Museum dealt with by Sykes, the shells there to which the name of *C limans* was given proved to be *C tricostalis*, Pilsbry

There will be other alterations made in the nomenclature of the Polyplacophora not yet definitely decided upon Ashby and other workers are dealing with the subject

Genus **Rhizorus,** Montfort 1810 replaces *Volvulella,* Newton 1891

Genus **Cylichnella,** Gabb 1873 replaces *Bullinella,* Newton 1891

Genus **Bullaria,** Rafinesque replaces *Bulla* Linne 1767

Genus **Ringicula,** Deshayes 1838

RINGICULA GRANDINOSA Hinds

1844 *Ringicula grandinosa* Hinds P Z S, Lond, p 96
1878 *Ringicula grandinosa,* Hinds Braz P L S, N S W, v II, p 78
1893 *Ringicula grandinosa,* Hinds Pilsbry, Man. Conch, v XV, p 409, pl 47, f 72

Hab—Port Albert (Worcester)

Obs—A stout shell, whorls rounded "The last large, subquadrate, rotund"

Genus **Tethys,** Linné 1758, replaces *Aplysia,* Linne 1767

Genus **Kerguelenia,** Mabille and Rochebrune 1887

This genus includes *Siphonaria stowae,* Verco, previously listed

Genus **Gadinia,** Gray 1824

GADINIA CONICA, Angas

1867 *Gadinia conica,* Ang P Z S, Lond, pp 115 and 220, pl 13, f 27

This name replaces that for the shell listed as *G angasi,* Dall.

Genus **Dentalium,** Linnaeus 1758

DENTALIUM ERECTUM Sowerby

1860 *Dentalium erectum* Sowb Thes Conch v III, p 99 pl 13 f 55

Hab—Taken off cable to Tasmania Bass Strait

Genus **Dacosta,** Gray 1858

This includes the species listed as *Clavagella australis* Lk

Family LATERNULIDAE replaces Anatinidae

Genus **Laternula,** Bolten 1798 replaces *Anatina* Lamarck 1809

Genus **Myodora,** Gray 1840

MYODORA ANTIPODUM E A Smith

1880 *Myodora antipodum* E A Smith P Z S Lond p 585 pl 53 f 7 7a

1913 *Myodora antipodum* E A Smith Suter Man N Z Moll p 1027 pl 55 f 10a

Hab—Taken off cable to Tasmania Bass Strait

Obs—Size of type Length 9 width 13 33 diam 2 mm Smith compares it with *M pandoriformis* Stutch

Genus **Thraciopsis,** Tate and May 1900

THRACIOPSIS SPECIOSA Angas

1869 *Thracia speciosa Ang* P Z S Lond p 48 pl 2, f 12

Hab—Frankston Port Phillip Dredged Western Port

Obs—Size of type Long 23 alt 12 lat 6 mm

Genus **Anapella,** Dall 1895

ANAPELLA TRIQUETRA Hanley

1914 *Anapella triquetra* Han Gat and Gab Vic Nat, v XXXI p 82

Genus **Syndesmya**, Recluz 1843

SYNDESMYA EXIGUA H Adams

1903 *Semele exigua*, H Ad Prit and Gat, these Proc, v XVI, p 113

1914 *Syndesmya exigua*, H Ad Lamy, Jour de Conch for 1913, v LXI, p 294, pl 8, f 4-6

Genus **Gari**, Schumacher 1817

GARI LIVIDA, Lamarck

1818 *Psammobia livida*, Lk Anim S Vert, v V, p 515

1818 *Psammotea zonalis*, Lk *Id* p 517

1903 *Gari zonalis* Lk Prit and Gat, these Proc, v XVI, p 113

1914 *Psammobia livida*, Lk Dautz and Fisch, Jour de Conch for 1913, v LXI, p 224, pl 7, f 4 6 and they state that *P zonalis* is a synonym

Genus **Pseudoarcopagia**, Bertin 1878

PSEUDOARCOPAGIA VICTORIAE, Gatliff and Gabriel

1914 *Tellina (Arcopagia) victoriae* Gat and Gab, Vic Nat, v XXXI, p 83

Genus **Hemidonax**, Morch 1870

HEMIDONAX AUSTRALIENSE Reeve

1914 *Hemidonax australiense*, Rve Gat and Gab, Vic Nat, v XXXI, p 83

Genus **Donax**, Linnaeus 1758

DONAX SORDIDUS, Reeve

1845 *Donax sordidus*, Rve Ann and Mag Nat Hist, v XVI, p 59

1848 *Donax sordida* Rve Krauss Sudafr Moll, p 6, pl 1, f 4

1854 *Donax sordidus*, Rve Conch Icon, v VIII, pl 5, f 32

Hab—Portland

Obs—Size of our shell Antero-posterior diameter 23, umbo-ventral diam 16 mm

Genus **Lioconcha**, Morch 1883

This includes the species listed as *Circe angasi* E A Smith

Genus **Callanaitis**, Iredale 1917

CALLANAITIS DISJECTA Perry

1903 *Chione disjecta* Perry Prit and Gat these Proc, v XVI p 122

1913 *Chione disjecta* Perry Suter Man N Z Moll, p 989 pl 61 f 5

Genus **Katelysia**, Romer 1857

This includes the species listed as *Chione strigosa* Lk *C scalarina* Lk and *C peronii* Lk

Genus **Clausinella** Gray 1851

This includes the species listed as *Chione placida* Phil

Genus **Gomphina**, Morch 1853

GOMPHINA UNDULOSA Lamarck

1914 *Gomphina undulosa* Lk Gat and Gab Vic Nat, v XXXI p 83

Genus **Macrocallista**, Meek 1876

This includes the species listed as *Meretrix disrupta* Sowb, *M planatella* Lk *M kingii* Gray and *M regularis* Smith

Genus **Bassina**, Jukes Browne 1914

This includes the species listed as *Meretrix paucilamellata*, Dkr and Jukes Browne selects it as the genotype

Genus **Pullastra**, Sowerby 1826

This includes the species listed as *Tapes fabagella* Desh, and *Tapes galactites* Lk

Genus **Myrtaea**, Turton 1822

MYRTAEA BOTANICA Hedley

1903 *Lucina brazieri Sowb* (*as Tellina*) Prit and Gat these Proc v XVI p 138 not *T brazieri*, Sowb 1869

1918 *Myrtaea botanica* Hed *nom mut* J R S N S W v LI for 1917 p 18 No 177

This genus also includes the species listed as *Lucina mayi* Gat and Gab

Genus **Codakia,** Scopoli 1777

This includes the species listed as *Lucina minima* Ten Wds, *L paupera* Tate and *L tatei* Ang

Genus **Divaricella,** Von Martens 1880

DIVARICELLA CUMINGI A Adams and Angas

1863 *Lucina (Cyclas) cumingi* Ad and Ang P Z S, Lond p 426 pl 37 f 20

1903 *Lucina (Divaricella) huttoniana* Vanatta Prit and Gat these Proc v XVI p 139

1913 *Divaricella cumingi* A Ad and Ang Suter Man N Z Moll p 913 pl 58 f 18

This is the species listed by Tenison Woods in his Tasmanian Census of Marine Shells as *Lucina divaricata* L

Genus **Cyamiomactra,** Bernard 1897

CYAMIOMACTRA BALAUSTINA Gould

1861 *Kellia balaustina* Gould Proc Bost Soc Nat Hist v VIII p 33

1909 *Cyamiomactra nitida* Hed Gat and Gab these Proc v XXII p 45

1914 *Cyamiomactra balaustina* Gould Gat and Gab Vic Nat v XXXI p 84

1915 *Cyamiomactra balaustina* Gould Hed P L S N S W p 699 pl 77 f 2 3

Genus **Coriareus** Hedley 1907

This includes the shell listed as *Montacuta semiradiata* Tate

Genus **Condylocardia,** Bernard 1896

CONDYLOCARDIA SUBRADIATA Tate

1888 *Cardiella subradiata* Tate T R S S A v XI p 62 pl 11 f 7

1908 *Condylocardia subradiata* Tate *Id* v XXXII, p 358 pl 17, f 25 28

Hab—Taken off cable to Tasmania, Bass Strait

Obs—Size of type Antero-posterior diam 13, umbo-ventral diam 12 5 mm

Genus **Venericardia**, Lamarck 1801

VENERICARDIA ROSULENTA, Tate

1887 *Cardita rosulenta* Tate T R S, S A, v IX, p 69, pl 5, f 3

1911 *Venericardia rosulenta* Tate Hed Zool Commonwealth trawler *Endeavour*, v I, p 97, pl 17, f 4

Hab—Taken off cable to Tasmania Bass Strait

Obs—Size of type Antero posterior diam 21, umbo ventral diam 17 mm Hedley records, *loc cit*, a specimen 45 mm in length

The shells listed as *Cardita* are now classed as *Venericardia*, and the genus *Cardita* is now used for those species previously listed as *Mytilicardia*

Genus **Neotrigonia**, Cossmann 1918

This includes the shell listed as *Trigonia margaritacea*, Lk

Genus **Nuculana**, Link 1807, replaces *Leda* Schumacher 1817

NUCULANA DOHRNI, Hanley

1861 *Leda dohrni*, Han P Z S, Lond, p 242

1871 *Leda dohrnii*, Han Sowb, Conch Icon, v XVIII, pl 9, f 54

Hab—Taken off cable to Tasmania, Bass Strait

The genus *Nuculana* includes the species already listed as *Leda*

Genus **Modiolus**, Lamarck 1799

This replaces *Modiola*, Lk, and the species listed as such will be changed accordingly

Genus **Musculus**, Bolten 1798, replaces *Modiolaria* Loven 1846

Genus **Pinctada**, Bolten 1798

This includes the shell listed as *Meleagrina margaritifera*, L.

[Proc Roy Soc Victoria, 34 (N S), Pt II, 1921]

Art XVI — Gold Specimens from Bendigo and their Probable Modes of Origin

By F L STILLWELL, D Sc

(Plate I)

[Read November 10th 1921]

The gold in the Bendigo quartz reefs occurs as particles of bright, yellow free gold, of high quality, containing about 30 parts per 1000 of silver Its occurrence can be divided into two general types—

(a) As particles associated with the dark laminated seams traversing the quartz,

(b) as particles embedded in white quartz

While these two general types are not confined to any particular form of reef it can be said that the first type is more characteristic of saddle reefs and leg reefs, and that the second type is more characteristic of " spurs " which are veins cutting across the strata The gold particles in the spurs are on an average, larger than the gold particles associated with the carbonaceous seams, but the latter may be more numerous, and have formed the main factor in the richest saddle reefs of Bendigo Such particles are occasionally so numerous as to form a sheet of gold along the lamina [1]

The particles of gold embedded in white quartz appear as shotty specks or as sheeted interlacings with quartz and sometimes ankerite The gold particles, like quartz, are allotriomorphic and do not assume their crystalline form except in rare cases in vugs The tendency of the gold towards its crystalline form is, however, often sufficient to produce more or less rounded, shotty particles, unless there exist obstructing or modifying circumstances The shotty particles sometimes are readily loosened and detached from the quartz, and are then spoken of as " loose gold " The modifying circumstances may develop during the later stages of growth of a vein if the quartz crystals grow at a more rapid rate than the gold crystals, or if the growth of the

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1 Gold Deposition in the Bendigo Goldfield, F L Stillwell Bull 4, Commonwealth Adv Council of Sci and Ind plate III fig 2

quartz crystals continues for a longer period than required for the gold crystals The tremendous crystallising pressure of the quartz, which is sufficient to force apart the walls of the vein, may then be partially directed against the growing crystals of gold, modifying them in the same way that gold is hammered in the production of gold leaf In this case the final result is a sheeted interlacing of gold with quartz, ankerite, and other minerals, with an appearance that has often suggested the infiltration of secondary gold in cracks in a quartz vein

The specimen illustrated in Fig 1 came from the Constellation saddle reef above the 622 feet level It shows a black slaty seam partly mixed with ankerite, pursuing its normal tortuous track through the quartz Several particles of gold, pyrite and galena occur in this specimen along this carbonaceous seam, including a well-formed cube of pyrite Particles of gold are embedded in the cube of pyrite, and appear to have formed the nucleus of the crystal

Another specimen, occurring near this cube in the same saddle reef shows an intimate mixture of gold galena and pyrite The mixture borders upon a carbonaceous lamina, visible on the side of the specimen but which is not revealed in the photograph (fig 2) The photograph illustrates a sliced surface of the specimen on which only a few fragments of carbonaceous matter are showing, but pyrite (P), gold (white) and galena (Ga) are distinguishable The mass of pyrite is embedded in quartz, but at the same time it is broken by veins of quartz, galena and gold The gold appears not only as nuclei of some of the pyrite, but also as a network of veins in the pyrite and in the galena

Without consideration of the process of formation of the vein the petrographical relations of the quartz and pyrite in these two specimens would indicate that—(1) pyrite crystallised before gold, and (2) that gold crystallised before pyrite The apparently contradictory character of these conclusions appears to me to disappear when the vein is viewed as a slow and steady growth, in which the quartz and each other mineral are slowly and continuously deposited from the initial stages up to the final stages of the formation of the vein The gold, pyrite and galena are localised in the quartz in these instances, partly by the precipitating action of the slaty residues, and, in a growing mixture of gold and pyrite, some of the pyrite may

be precipitated before some of the gold, and some of the gold before some of the pyrite. The mutual relationships of the solubilities and concentrations of the different vein minerals, which might have been expected to produce a more or less characteristic order of deposition have been disturbed by the presence of foreign precipitating matter.

A specimen of a different and rare type at Bendigo is illustrated in Fig. 3. It consists of a thin plate of gold, with a small fragment of attached quartz, terminating in a crystal of gold. The specimen is 3 cm. long, weighs 2 dwts. 14 grs., and is shown in the photograph with a magnification of 2. It was found in a quartz spur in sandstone about two feet wide in the stopes on the Victory spurs, 580 feet south, 1235 feet level, in the Carlisle mine. The gold crystal occurred in a vug, terminating the plate of gold in the same way as the associated quartz crystals in the same vug grew out from the mass of quartz. The dominating faces of the crystal are those of the octahedron. The solid angles of the octahedron are replaced by small faces of the cube, and the edges of the octahedron are replaced by faces of the rhombicdodecahedron. For nearly 1 cm. behind the terminating crystal, crystalline faces of gold can be seen on the plate of gold. It is quite clear that this small nugget of gold is as essential and primary a part of the vein as the quartz crystals that form the bulk of the vein. Had the gold not assumed the platy and crystalline form, the occurrence might have been similar to the gold wire whose occurrence in a quartz vug has previously been recorded.[2]

Another rare specimen obtained from the same stopes, at the 1235 feet level, in the Carlisle mine, is illustrated in Fig. 4. This is a fragment of a very small, but very rich, spur, which traversed a thick bed of slates on the eastern side of the stopes. The thickest part of the vein in the specimen is 5 mm., in which are embedded two isolated crystals of sphalerite, with a little admixed pyrite. A few small specks of gold are embedded in the quartz, but the main mass of gold in the specimen occurs as a thin film, bounding the quartz and the slate. The gold film shows irregularities, but is fairly continuous, and, when the slate is broken away, has the appearance of gold paint on the wall of the vein. Towards one end of the specimen the thick-

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2 The Factors influencing the Deposition of Gold in the Bendigo Goldfield. F. L. Stillwell. Bull. No. 8 Adv. Council of Sci. and Industry, plate V, fig. 2.

ness of the quartz vein diminishes, and becomes almost pure gold An interesting feature of the specimen is shown in the illustration, and consists of a number of gold platy riffles standing out from the vein at right angles to the wall These riffles are on the whole parallel to the cleavage of the slate, and represent gold that has been deposited in the cleavage cracks from solutions traversing the course of the vein The feature exists on both sides of the vein It is very clear from this specimen that the slate has been a precipitating agent for the gold

Another specimen from the same gold shoot, and the same mine can also be recorded, though it does not lend itself to illustration It was obtained from the 1264 feet level, adjoining the plane of a small west dipping fault A spur, which varies in thickness from ½ inch to 1½ inches, butts against the fault plane and contains pyrite and colours of gold Projecting from the wall of a small branching spur, which forms the fault plane, is a nest of pyrite cubes, and the wall of the fault and spur is mostly covered with a film of gold, which also extends into the fractures of the associated slate These two specimens are rare, and at first glance the films of gold paint suggest the occurrence of secondary gold, i e, gold which has been leached from the gold bearing spurs, and precipitated by the slate The small fault is believed to have existed prior to the vein formation and gold might have been precipitated from the primary solutions circulating along it, or from subsequent secondary solutions The great depth of the occurrence of 1264 feet below the surface is a fact in strong opposition to a theory of downward secondary enrichment, while the association of the gold with the sulphides is more consistent with its being of primary origin Even if it were claimed that these occurrences indicate the presence of secondary gold, it must be remembered that they are rare Frequent inspections of mining operations on this gold shoot in the Carlisle mine, which, during the fourteen months preceding September, 1921, produced 15,712 ounces of gold, valued at £84,761, failed to yield any evidence recognisable as being characteristic of secondary enrichment It may therefore be fairly concluded that the gold in the spurs is primary, and that the existence of the gold shoot is dependent on primary causes

PLATE I.

Fig. 1. Quartz, showing gold (dark), embedded in a cube of pyrite. From saddle reef above 622 feet level, Constellation mine. Mag. 2.

Fig. 2. Quartz carrying pyrite gold and galena. The pyrite (P) is intersected by veins of quartz, galena (Ga) and gold (white). From saddle reef above 622 feet level, Constellation mine. Mag. 2.

Fig. 3. Thin plate of gold terminating in a crystal of gold. Stopes 580 feet south, 1235 feel level, Carlisle mine. Mag. 2.

Fig. 4. Rich spur in slate, showing a number of gold platy riffles standing out from the vein at right angles to the wall of the spur. The dark area (B) is a crystal of zinc blende embedded in the vein, and the hackly appearance of the edge of the vein is due to gold. Eastern side of stopes, 580 feet south, 1235 feet level, Carlisle mine. Mag. 2.

Fig 1

Fig 2.

Fig 3

Fig 4

[Proc. Roy. Soc. Victoria, 34 (N.S.), Pt. II., 1922.]

Art. XVII.—*On a Fossil Filamentous Alga and Sponge-Spicules forming Opal Nodules at Richmond River, N.S.W.*

By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

(With Two Text Figures.)

[Read 10th November, 1921.]

Source of Specimens.

The samples of common opal from the diatomaceous deposits of the Richmond River at Tintenbar, New South Wales, now described, were handed over to the National Museum Collection by Mr. R. H. Walcott, Curator of the Technological Museum, Melbourne They were received by Mr. Walcott from Mr. G. N. Milne, of the Salvation Army, at Bayswater, on the 18th of December, 1919.

In response to Mr. Walcott's desire to know something of the microscopic nature of these samples, I took thin slices from two of the pieces, which gave different results; in the one case a spicule-rock being revealed, originating from freshwater sponges, and in the other the matted thalli of a confervoid freshwater weed, probably of the genus *Cladophora,* and now silicified.

Literary Notes on the Deposit.

Professor Liversidge, writing on the siliceous deposits from the Richmond River, New South Wales,[1] refers to this rock as resembling "the deposits thrown down by hot springs or geysers." He records the presence of wood opal and remains of ferns (Pteris) and seeds, one of the latter being named by von Mueller, *Liversidgea oxyspora,*[2] to which is also referred a leaf fragment.

J. Milne Curran, in writing on precious stones in New South Wales,[3] on p. 258 of the reference quoted, says, "I have more than once received specimens of diatomite from the Richmond River, which were in part converted into a true opal."

1. Journ. and Proc. R. Soc. N.S. Wales, vol. X. (1876), 1877, pp 237-240.
2. Loc. cit., p 239, plate.
3. Journ. and Proc. R. Soc., N.S. Wales, vol. XXX (1896), 1897

The occurrence of this fossil confervoid is of especial interest on account of the rarity of fossil remains of this character Impressions of confervoid like structures in rocks were named *Conferites* by Brongniart in 1828

Bornemann also described a Cambrian fossil from Sardinia, to which he gave the name of *Confervite chantransioides* the filaments of this fossil have a diameter of 6 7 μ [8]

Dr C D Walcott has lately described a genus of algae *Marpolia*[9] from the Middle Cambrian shale of the Burgess Pass Quarry British Columbia This form closely resembles the habit of growth in *Cladophora* though no actual structure of the thallus was determinable It is relatively larger in size than the form here described from the opal Dr Walcott refers the genus *Marpolia* to the *Cyanophyceae* but a comparison is made with *Cladophora* (*Chlorophyceae*)

Some forms of the *Codiaceae* are also filamentous and branching and are not unknown in fossil deposits but these appear to be of marine habitat

Age—Late Cainozoic probably Pleistocene

Description of Spicules in Opal (Fig 2)

The majority of the spicules found in one specimen examined are of the typical *Spongilla* type being straight curved or slender fusiform some are nearly cylindrical and pointed at the extremities whilst others are arcuate and much thicker in the middle A few extremely slender needle like forms are present The surfaces are apparently all more or less spinulose These appear to belong to the genus *Spongilla* whilst a few smooth forms may belong to *Meyenia* Very few traces of amphidiscs occur but those seen are of the type of *Spongilla capewelli* a species named by Bowerbank from specimens occurring at Lake Hindmarsh Victoria[10] A portion of what appears to be the head of a birotulate spicule with a denticulate margin shows some resemblance to the form described by Prof Haswell as *Meyenia ramsayi*[11]

Regarding a similar diatomaceous and sponge spicular deposit, from the Warrumbungle Mountains Mr R Etheridge (junr)

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8 Kais Leop Carol Deutsche Akad Naturfors her vol LI 1887
9 Smithsonian Misc Coll vol LXVII No 5 1919 p 283
10 Proc Zool Soc Lond 1863 p 447 pl XXXVIII fig 3
11 Proc Linn Soc N S Wales vol VII 1883 p 210

recognised in it[12] *Spongilla* sp, and this was confirmed by Dr Hinde, who also determined the presence of amphidiscs, belonging the genus *Meyenia*[13] The diatomaceous deposits of the Warrumbungle Mountains are, however, of greater age than those

Fig 2 Spicules in Opal

described above, for Prof David has shown[14] that they are interbedded with a trachytic tuff, which has yielded leaves of *Cinnamomum Leichhardti*, Ett

12 Ann Rep Dept Mines N S Wales for 1887 (1888) pp 165 166
13 See Card and Dun Rec Geol Surv N S Wales vol V 1897 p 148
14 Proc Linn Soc N S Wales vol XXI 1896 pt 2 p 265

[Proc. Roy. Soc. Victoria 34 (N.S.), Pt. II., 1922].

Art. XVIII.—*On the Changes of Volume in a Mixture of Dry Seeds and Water.*

By ALFRED J. EWART, D.Sc., Ph.D. F.R.S.
(Professor of Botany and Plant Physiology in the University of Melbourne).

[Read 8th December, 1921]

If a quantity of dry peas is placed in a bottle filled with water, and provided with an open upright tube, it will be noticed that as the seeds swell the level of water in the tube rises, indicating a total increase of volume, and that after several hours the level of liquid in the tube falls again. The following observations illustrate this: The bottle used had a capacity of 1050 c.c., and 10 cms. of the erect tube contained 2.4 c.c. Peas were dried at 80°C., and the bottle two-thirds filled with them, and then filled up with water. The temperature of the peas was 20°C., and of the water 13.6. The increase or decrease of volume was measured from the height of liquid in the tube. The total

Temperature.	Time	Total Increase or Decrease of Volume.
16·3°C	12 a.m.	0 0c.c
—	12.30 p.m	+0·36 c.c.
16·3°C	3 p.m.	+5 6c.c.
16·4°C.	3.50 p.m.	0·0c.c.
15·8°C.	10 p.m.	−18·7c.c.
13·8°C.	10 a.m.	−10·8c.c.

volume therefore first increases, then decreases by a still greater amount, and finally increases again. The final increase is apparent only, and is due to the production of small bubbles of gas by anaerobic respiration. It begins, however, before the bubbles actually appear.

This simple observation has long been known, and has been variously explained It has even been stated to be a good way of demonstrating the expansion of seeds in water, ignoring the fact that the expansion of the seeds should be proportional to the amount of water they absorb, leaving the total volume unaltered.

The variation in the total volume might in fact be due to a variety of causes, and since seeds have specific structure, it need not follow the same course for all seeds. In regard to the first increase of total volume, this might be the result of the slight rise of temperature when dry seeds absorb water. Hence the experiment was repeated with the peas and water at the same original temperature (13.6°C.), the mixture being well stirred to remove any adhering air bubbles.

Temperature	Time	Total Increase or Decrease of Volume
13.7°C.	10 a.m.	0.0 c.c.
14.3°C.	12.10 p.m.	+6.9 c.c.
14.8°C.	3.20 p.m.	+3.9 c.c.

In this case a pronounced contraction of volume took place, while the temperature was still rising. The fact that the alterations of volume are far greater than any fluctuations due to changes of temperature can also be shown by direct estimation.

Using a bottle of 1050 c.c. capacity, with a tube attached, of which 10 cms. = 2.4 c.c., the actual expansion of the water can be calculated from the formula—

$$v_t = v_0(1 + \alpha t)$$

where $\alpha = 1.5 \times 10^{-4}$ between 10°C. and 20°C.

The increases of volume per 1°C. at various temperatures are given:

		Estimated Increase of Volume	Observed Rise in Tube
Between	10–12°C.	0.1050 c.c. = 0.44 cms.	
	12–14°C.	0.1416 c.c. = 0.59 cms.	
	14–16°C.	0.1512 c.c. = 0.63 cms.	0.68 cms.
	16–18°C.	0.1824 c.c. = 0.76 cms.	} 0.82 cms.
	18–20°C.	0.1920 c.c. = 0.80 cms.	

In spite of the fact that the observed rise only gives the apparent expansion, it is greater than the theoretically calculated absolute expansion, but the methods used were not very refined, and were merely intended to show that the fluctuations of volume due to slight changes of temperature are small compared with those caused by the swelling seeds.

The increase of total volume with swelling peas is most pronounced when the seed coat has become markedly wrinkled, sug-

gesting that the increase of volume is connected with wrinkling of the seed coat This is easily proved by using split peas, in which case the total volume does not undergo any preliminary increase, but decreases from the outset until the final rise due to the production of gas The first experiment was carried out with air-dry material, the second with material oven-dried at 80°C The original total volume was 1050 c c, and the receiver was two thirds filled with the split peas It will be seen that the contraction is much less with the air dry material which already contained 16 per cent of water

AIR DRY SPLIT PEAS

Temperature	Time	Total Increase or Decrease of Volume
11°C	10 a m	0 0c c
11 5°C	12 30 p m	−1 5c c
12 1°C	11 30 p m	+0 77c c
OVEN DRIED SPLIT PEAS		
13 7°C	11 a m	0 0c c
15 6°C	1 p m	−6 1c c
13 3°C	10 30 p m	+0 53c c

Similar results were obtained with split lentils, the material being first washed with spirit and then rapidly with water to remove adherent air bubbles

SPLIT LENTILS AIR DRIED

Temperature	Time	Total Increase or Decrease of Volume
13 3°C	10 50 a m	0 0c c
13 8°C	2 30 p m	−3 55c c
14 3°C	6 p m	3 15c c
SPLIT LENTILS DRIED AT 80° C		
13 4°C	11 25 a m	0 0c c
13 4°C	7 40 p m	−6 5c c
13 3°C	5 a m	−5 66c c

The observations were discontinued as soon as a distinct increase of volume begins, for this is merely due to the appearance of gas bubbles, and proceeds rapidly once it has commenced

Since the first increase of total volume shown with whole peas is due to the wrinkling of the seed coat, the suggestion may be made that the wrinkles are due to local regions of the

skin absorbing water, and expanding more rapidly than others This would result in a tendency to a partial vacuum beneath each wrinkle, and this would hasten the drawing in of water, and at the same time increase the total volume of the mixture of seeds and water If this were so, then under pressure the first expansion should be either greatly decreased or suppressed

For this purpose a stout separating funnel was used Peas and water were introduced at the top which was then sealed To the lower end a long-armed U tube was attached This contained a water column continuous with that in the funnel Mercury was then poured into the open arm of the U tube until the difference of level was 76 cms After each reading the mercury was brought up to the original level if contraction had taken place or reduced to the same level with the aid of a pipette if expansion had occurred The temperature varied within 1°C during the experiment a maximum rise of 1°C being shown after three hours when the total volume had begun to decrease The total initial volume was 1080 c c and a two thirds charge of oven dried peas was used

Time	Total Increase or Decrease of Volume	
3 p m	[0 0c c]	0 0c c
3 35 p m	[+2 3c c]	0 10c c
4 p m	[+4 7c c]	+0 28c c *
4 40 p m	[+6 1c c]	+0 76c c
5 p m	[+2 1c c]	0 0c c.
8 p m	[2 4c c]	−2 0c c
9 p m	[3 0c c]	−4 8c c
9 a m	[−1 1c c]*	5 6c c †
10 a m	—	−5 6c c

* Seeds beginning to wrinkle
† Seeds fully swollen

Owing to the pressure the final expansion due to the liberation of gas bubbles is long delayed The figures in brackets give the expansion and contractions of a similar volume of peas and water not under pressure At * gas production began preventing the full contraction of volume

It will be noticed that under pressure there is a slight contraction of volume before the expansion due to the wrinkling of the seed coat begins This is probably the result of the pressure on air in the intercellular spaces of the cotyledons These are not entirely obliterated on drying, as can be seen by exam-

ining sections of dry peas in pure glycerine A large receiver with a manometer attached showed an unchanged pressure of –76 cms for an hour after exhaustion with a double Geryck pump It was then filled with dry peas, and again rapidly exhausted The exhaustion required a few more strokes, and on standing for an hour the pressure increased from –76 cms to –72 cms, then remaining stationary This shows that the dry peas do actually contain a little air

In the case of all seeds in which the seed coat wrinkles more or less during absorption, the total volume shows a preliminary increase, followed by a decrease, as in the case of peas, and a final increase of volume, which is only apparent and is due to the production of gas It usually begins before any actual gas appears but is then due to gas forming in the intercellular spaces of the seed, and driving out some of the water contained in them

TICK (HORSE) BEANS TOTAL VOLUME 1065 CC ½ CHARGE OF BEANS

Temperature	Time	Total Increase or Decrease of Volume
11 4°C	10 40 a m	0 0c c
12 2°C	5 p m	+9 98c c
12 5°C	7 30 p m	+9 28c c
11 7°C	10 15 a m	2 54c c
12 0°C	10 p m	4 39c c
11 6°C	10 a m	+2 5c c

HARICOT BEANS TOTAL VOLUME 1055 CC ½ CHARGE OF BEANS

Temperature	Time	Total Increase or Decrease of Volume
12 5°C	3 p m	0 0c c
12 65°C	3 40 p m	+2 5c c
13 3°C	7 45 p m	–4 6c c
11 8°C	10 a m	–10 08c c
12 6°C	5 15 p m	–14 6c c
12 6°C	7 p m	11 2c c *

* No bubbles of gas as yet formed

In the case of barley and cereal grains in which the integuments do not wrinkle while absorbing water, the total volume contracts from the commencement until the rise due to gas production begins

The following tests give the contractions obtained with air-dried and oven-dried barley The total volume was 1056 and

1060 c.c. respectively. The receiver was two-thirds filled with barley, after this had been rapidly washed with spirit to remove air, and with water to remove light grain.

BARLEY (AIR DRIED)

Temperature	Time.	Total Contraction.
13·8°C.	zero	0·0c.c.
13 5°C.	24 hours	−2·38c.c.
BARLEY (OVEN DRIED).		
12 4°C	zero	0·0c.c.
12 4°C.	6 hours	−3 02c.c

It is of interest to compare these contractions with those of agar and gelatine when swelling in water. Ordinary flake or strip agar or leaf gelatine cannot be used, as it is impossible to obtain a mixture with water free from air, and they swell too rapidly Nelson's strip gelatine gave good results, and granulated agar was used, the granules swelling to the size of kidney beans or broad beans in water. In both cases a rise of temperature of 0.5 to 1°C. takes place, but the final readings were taken when the temperature had fallen approximately to the calorimeter level again. The contraction of volume is small, and it takes place almost wholly in the first hour with the gelatine, and in the first seven hours with the agar, i.e., long before either are fully swollen.

GELATINE. 150 GRAMS TOTAL VOLUME, 1050 cc

Temperature	Time	Contraction of Volume.
15 5°C.	zero	0 0c.c.
15 5°C.	70 minutes	0·912c.c.
AGAR. 50 GRAMS. TOTAL VOLUME, 1056 cc.		
15·2°C.	zero	0·0c.c.
15 1°C.	7 hours	0·65c.c.

At a temperature of 15°C., 1000 c.c. of water would undergo a decrease of volume of 0.495 c.c. under an increased pressure of 10 atmospheres. Hence a decrease of 0.912 c.c. indicates an increased pressure of 20 atmospheres. This is exercised on the water by the gelatine in the process of swelling. The pressure is probably much greater than this at first, and lessens as the gelatine swells throughout, but on the other hand, more water

is under compression The maximal total contraction will be given at some intermediate point between commencing absorption and complete absorption and swelling

There may be two reasons for the greater contraction of volume with swelling seeds as compared with the gelatine Using equal volumes of barley, haricot beans and peas the maximal contraction obtained varied from 2 5 to 6 c c but in all cases were greater than with gelatine This would indicate absorption pressures of 50 to 120 atmospheres An organised colloid like cellulose, may be capable of showing a higher absorption pressure than an unorganised one like gelatine In addition a certain amount of solution may take place in the seed as water is absorbed Tamman[1] has shown that a volume of a solution under one atmosphere pressure expands when heated like a similar volume of water under a constantly higher pressure i e a solution has a high internal pressure due to the solute This action is a general one independently of whether the solute is an electrolyte or a non electrolyte In other words the minimum volume temperature of water is lowered by the presence of a solute It follows therefore that as some of the food constituents of the seed begin to dissolve the total volume may tend to undergo a slight decrease as the result of the action of the solute There are however certain exceptions to this rule For instance a mixture of ammonium chloride and water expands on solution so that a 6 85 per cent solution has an increased volume of 0 266 c c (100 266 c c instead of 100 c c) [2] Hence it is impossible to say exactly what part may be played by dissolving solids in producing a contraction of the total volume

In addition if cellulose obtained from a colloidal solution has the same composition as that in the cell wall the fact that it has a higher density may indicate that in penetrating the cell wall the water molecules may partly enter empty intermicellar spaces, thus producing a contraction of total volume It is at least evident that the changes of volume in a mixture of dry seeds and water are by no means simple phenomena, but are due to various interacting and in some cases antagonistic factors

1 G Tamman Ueber die Beziehungen Zwischen den inneren Kraften and Eigenshaften der Lösungen Voss Hamburg and Leipzig 1907

2 Happart Bulletin Inst Liege 1903

Summary.

Marked changes of the total volume are shown when dry seeds absorb water.

If the seed coat wrinkles, there is first an expansion, then a contraction, and then a final rise which is due to the production of gas in the seed. The changes are not the result of alterations of temperature. The wrinkling is due to unequally rapid absorption, partial vacuums forming under the wrinkles, which hasten the indrawal of water. If the seed coat does not wrinkle there is no preliminary expansion, and the contraction is due as in gelatine to the compression of the absorbed water.

Using similar methods as with the seeds, the contraction obtained with gelatine indicated a pressure of 20 atmospheres, but with seeds as much as 50 to 120 atmospheres pressure was indicated. This may be due partly to the greater imbibition pressure of organised cellulose as compared with gelatine, and partly to the influence of solutes increasing the internal pressure of the water within the seeds.

[PROC. ROY SOC VICTORIA 34 (N S), PT II, 1922]

ART XIX—*Further Researches into the Serological Diagnosis of Contagious Pleuro Pneumonia of Cattle* *

BY G G HESLOP, D S O, D V Sc, D V H
(Walter and Eliza Hall Fellow)

(Communicated by Professor H A Woodruff)

[Read 18th December, 1921]

Introduction

In a former publication by the writer on the Serological Diagnosis of Contagious Pleuro-pneumonia of Cattle (1),[1] a description was given of research work carried out at the Veterinary Research Institute, Melbourne University, under the terms of the Walter and Eliza Hall Research Fellowship in Veterinary Science The main object of the research was to endeavour to elaborate a sero-diagnostic method for the detection of Contagious Pleuro-pneumonia in affected cattle

Agglutination tests, using both the macroscopic and microscopic methods of testing for agglutinins, were tried, but failed to reveal the presence of agglutinins in the sera of animals *naturally* affected with contagious pleuro-pneumonia

Agglutinins however were demonstrated macroscopically in the serum of an experimental animal (calf) which had been injected subcutaneously in the tail with active pleuro-pneumonia virus, and which subsequently received two further injections subcutaneously behind the shoulders at intervals of 10 to 12 days, one injection being of pleuro-pneumonia virus, the other of pure culture [2] Agglutination tests, using the microscopic method with dark ground illumination, were not carried out, and it has been considered desirable to carry out further examinations of culture and various test sera under the microscope with dark ground illumination so as to determine whether, by using that method, the presence of agglutinins could be detected in the sera of naturally affected cattle

(* Being the Final contribution in a Thesis approved for the degree of Doctor of Veterinary Science in the University of Melbourne)

1 Reference is made by number to Literature Cited p 198

2 Loc cit p 177

Complement fixation tests were carried out, and a description was given of a complement fixation test which has been applied for the diagnosis of contagious pleuro-pneumonia in cattle. The technique of this test, however, is considered to be too intricate and laborious to allow of its adoption as a routine diagnostic method. Further, it was found that the test was only approximately accurate in its results, for, on testing the sera of 63 different animals (cattle) a positive result was obtained with the serum of one animal which, on subsequent post-mortem examination, showed no lesions of contagious pleuro-pneumonia in the lungs Two other animals gave reactions which could not be definitely interpreted either as negative or positive. On submitting these two animals to post mortem examination, no lesions of contagious pleuro-pneumonia were discovered.

The results of the tests of these 63 serum samples can be conveniently tabulated as follow:—

Number of serum samples tested—63	
Gave positive reaction to test and showed lesions of C.P P. on P M - - - - - -	13
Gave positive reaction to test and showed no lesions of C P P on P M. - - - - -	1
Gave negative reaction to test and showed lesions of C.P.P. on P M. - - - - -	0
Gave negative reaction to test and showed no lesions of C P P. on P M - - - - -	47
Gave border line reaction to test and showed lesions of C.P.P. on P.M. - - - - -	0
Gave border line reaction to test and showed no lesions of C.P.P. on P M - - - - -	2

At first sight this tabulation appears to show that the test has been fairly accurate in differentiating between animals which were and which were not affected with contagious pleuro-pneumonia, but if the figures are analysed carefully, it is found that the percentage of error is an unduly large one. Sixty-three serum samples were tested, and of the reactions obtained, 60 were verified by the post-mortem findings, while the other three were not. In a total of 50 negative sera tested, 47 reacted negatively, and three gave reactions which were not negative, an error of 6 per cent. Fourteen serum samples gave positive reactions; 13 of these were verified by the post-mortem findings, one was not; an error of approximately 7.14 per cent. If we add to these

14 positive reactions the two "doubtful" reacting sera, we have a total error of three in 16, or 18 75 per cent, which is a very high percentage of error in a diagnostic test

As it could not be claimed that the complement fixation test described was sufficiently accurate to warrant its general application as a diagnostic method for contagious pleuro-pneumonia, further research work was considered desirable in order to ascertain—

1 Whether the test could be rendered more accurate in its results
2 Whether the technique for the test could be simplified without reducing the accuracy of the reaction
3 Whether certain extracts of tissue and of culture possessed greater value as antigens for the test than the antigen previously used

The present paper deals with this further research work which has been carried out in the laboratories of the Veterinary Research Institute during the current year I desire to express my grateful appreciation and thanks to Dr S S Cameron Director of Agriculture, Victoria, Professor H A Woodruff, Director of the Veterinary Research Institute, Melbourne University, W A N Robertson, Esq, B V Sc, Chief Veterinary Officer, Department of Agriculture, Victoria, Dr L B Bull, Deputy Director South Australian Laboratory of Pathology and Bacteriology, Dr W J Penfold, Director of the Commonwealth Serum Laboratories, and the Staff of the Live Stock Division, Department of Agriculture, Victoria, for the assistance they have rendered me during the course of this research

Fermentation Reactions of the Organism of Contagious Pleuro Pneumonia

With reference to the fermentation reactions of the organism of contagious pleuro pneumonia previous work had shown that the organism would grow in Martin's broth plus ox serum to which either saccharose, glucose, maltose or lactose had been added, but would not grow in similar media to which the alcohol derivatives mannite and dulcite had been added [3] As the mannite and dulcite used was laboratory stock several years old it was decided to repeat the experiment, using new samples of mannite and dulcite

3 Loc cit p 170

Experiments have accordingly been made with mannite and dulcite (Gurr), using adequate controls, and it has been found that growth of the organism occurs in both mannite and dulcite Martin's broth, but no acid or gas is developed in the medium as a result of the growth which takes place. Andrade's indicator has been used as the indicator for the experiments. The mannite and dulcite were added to the broth media in the proportion of 2 per cent. in each case. Growth was apparent in from four to five days after incubation at 37°C.

The fermentation reactions of the organism of contagious pleuro-pneumonia are therefore as follow:—

	Saccharose	Glucose	Maltose	Lactose	Mannite	Dulcite
Acid	–	+ +	+	–	–	
Gas	–	–	–	–	–	–

Growth takes place with each reagent.

+ = Acid. + + = Strongly acid – No reaction.

Complement Fixation.

Attempts have been made to simplify the technique for the complement fixation test, but it has been found that with each attempted modification of the technique already laid down further inaccuracies have occurred in the results. As a result of the further experiments carried out it is now apparent that the best results with the complement fixation test are obtained when the technique set out in detail in the writer's previous article is carefully followed.

Various new preparations have been tested as antigens for the complement fixation test. Certain of the preparations tested have shown some ability to fix complement in the presence of a positive serum, while with others no visible fixation of complement has occurred at all. In all cases the new preparations tested have been proved to be inferior in antigenic value to the alcoholic extract of subepidermal tumour tissue used in the experiments reported fully in the writer's previous article.

The new preparations tested as antigens were as follow:—

Antigen 1.—An alcoholic extract of the dried residue after rapid evaporation of a seven days' old culture of the organism of contagious pleuro-pneumonia in Martin's broth ox serum. On testing, this extract was found to possess no demonstrable antigenic value.

Antigen 2—An alcoholic extract of three months old culture of the organism of contagious pleuro pneumonia in Martin s broth horse serum On testing this extract was found to possess no demonstrable antigenic value

Antigen 3—An alcoholic extract of normal ox heart muscle On testing this extract was found to possess no demonstrable antigenic value

Antigen 4—An alcoholic extract of guinea pig s heart muscle On testing this extract was found to possess only slight antigenic value No fixation of complement occurred with known negative sera while with known positive sera in three out of ten samples tested there was slight inhibition of haemolysis The remaining seven positive samples gave negative reactions

Antigen 5—An alcoholic extract of diseased lung taken from an active case of contagious pleuro pneumonia On testing this extract was found to possess no demonstrable antigenic value

Antigen 6—An alcoholic extract of fresh sub epidermal tumour tissue removed from behind the shoulder of calf 10 after an experimental subcutaneous inoculation of pure virus in that region On testing this extract was found to possess a fairly high antigenic value No fixation of complement occurred when it was tested with 10 different samples of known negative sera while with 10 different samples of known positive sera nine showed fixation of complement varying from partial to complete fixation the other known positive serum reacted negatively This extract was unsatisfactory in that it was highly anti complementary in any quantity tested of a 1 in 10 dilution with saline Even in a 1 in 20 dilution it was anticomplementary excepting in the smallest amounts 0 05 c c of 1 in 20 dilution was the unit used for the tests already referred to

Antigen 7—An alcoholic extract of the dried residue of evaporated culture (Antigen 1) to which was added 0 4 per cent chlosterin

Antigen 8—An alcoholic extract of three months old culture in Martin s broth horse serum (Antigen 2) to which was added 0 4 per cent chlosterin

Antigen 9—An alcoholic extract of ox heart muscle (Antigen 3) to which was added 0 4 per cent chlosterin

Antigen 10—An alcoholic extract of guinea pig s heart muscle (Antigen 4) to which was added 0 4 per cent chlosterin

Antigen 11—An alcoholic extract of fresh subepidermal tumour tissue from experimental Calf 10 (Antigen 6) to which was added 0 4 per cent chlosterin

Antigen 12—An alcoholic extract of dried subepidermal tumour tissue from Calf 10, to which was added 0 4 per cent chlosterin

The chlosterin used in the preparation of Antigens 7, 8, 9, 10, 11 and 12 was a sample freshly prepared in the Physiological laboratories of the Melbourne University The extracts to which chlosterin was added were found to be so highly anticomplementary that they were useless for testing purposes Antigens 11 and 12 were again made up but with only half the quantity of chlosterin added i e, 0 2 per cent They were found on testing to be still too anticomplementary for use in a complement fixation test

Agglutination Tests

A number of blood samples were obtained from animals which were found to be infected with contagious pleuro-pneumonia at the time of slaughter and post mortem examination Blood samples were also obtained from a number of animals who were known not to be affected, or to have been in contact with the disease In this manner a large number of ' known positive " and ' known negative ' serum samples have been acquired, and these sera have been used as test sera in the agglutination tests

Microscopic Agglutination

Agglutination tests with known positive and known negative sera using the microscopic method with dark ground illumination have been carried out with very unsatisfactory results With a known positive serum agglutination can be observed invariably in a dilution of 1 in 20 in about three and a-half hours after mixing Unfortunately, however, the majority of known negative sera tested also showed agglutination in the same dilution in the same time In dilutions of 1 in 30 only five out of eight positive sera tested showed agglutination, while two out of 8 negative sera tested also showed agglutination in the same dilution In dilutions of 1 in 35 two positive sera out of eight tested showed agglutination while none of the eight negative sera tested showed agglutination in that dilution No serum, either positive or negative, showed agglutination in a dilution of 1 in 40

It is worthy of note that the positive sera which showed agglutination in three and a-half hours in dilutions of 1 in 30, and 1 in 35, were sera taken from animals affected with the disease in an acute form

The results of agglutination tests under the microscope with dark ground illumination can be conveniently tabulated as follow —

Dilutions

NUMBER OF CASES SHOWING AGGLUTINATION IN ANY DEGREE

	1 in 5	1 in 10	1 in 15	1 in 20	1 in 25	1 in 30	1 in 35	1 in 40
Known positive sera (total tested=8)	8	8	8	8	7	5	2	0
Known negative sera - (total tested=8)	8	8	7	6	3	2	0	0

No recognisable agglutination takes place under the microscope at room temperature until at least one hour after the mixture of culture and serum has been made The agglutination is apparently completed in approximately three and a-half hours after mixing, and the results tabulated above were obtained from readings made three and a half hours after the mixture of culture and serum had been made

The cultures used in these tests had been grown in Martin's broth ox serum (Reaction PH—8 4 approximately) and subcultured every seven to eight days until the eighteenth to twentieth subculture stages had been reached Each subculture at the time it was used in a test was from six to eight days old

A live culture was used in each case

There is a considerable amount of technical difficulty in the conduct of microscopic agglutination tests in which dark ground illumination is an essential factor The fact that the organism of contagious pleuro-pneumonia is of such minute size adds to the difficulty of successfully carrying out such tests

Altogether the results of these microscopic agglutination tests are disappointing in that they do not offer a solution of the problem of diagnosing the disease in the living animal They are of very great interest, however, in that they furnish the first instance in which agglutinins have been demonstrated to occur in the sera of animals *naturally* infected with contagious pleuro-pneumonia.

Macroscopic Agglutination

The results of a considerable amount of work on the macroscopic agglutination test for contagious pleuro-pneumonia have already been published by the writer, who was able to demonstrate the presence of agglutinins in the serum of a hyper-immunised calf (Calf 1), but could not demonstrate them in the sera of animals infected with contagious pleuro pneumonia naturally acquired Calf 1 had reacted to a primary subcutaneous inoculation of active pleuro-pneumonia virus in the tail, and subsequently received two further subcutaneous inoculations of virulent material (one of active pleuro pneumonia virus, the other of pure culture) behind the shoulders at intervals of 10 to 12 days Serum from Calf 1 in dilutions up to 1 in 70 caused macroscopic agglutination of a culture of the organism of contagious pleuro-pneumonia, while the sera of non immunised animals used as controls had no agglutining effect upon a similar quantity of the same culture [4]

The presence of agglutinins in the sera of hyper immunised bovines has been confirmed by Titze and Seelemann (2) who have recently published the results of their experiments in which they were able to demonstrate the presence of specific agglutinins in the serum of a hyper immunised heifer and of a hyper immunised bull

While specific agglutinins can be demonstrated in the sera of hyper-immunised cattle all attempts by the writer to demonstrate the presence of agglutinins in the sera of animals naturally infected with contagious pleuro-pneumonia have, until recently, been unsuccessful, the conclusion arrived at by the writer in his previous publication being as follows —

" Agglutinins could not be demonstrated, in the sera taken from bovines known to be affected with contagious pleuro-pneumonia, by the usual macroscopic and microscopic methods of testing for agglutinins Therefore an agglutination test apparently has no value as a means of differentiating between animals which are, and which are not, affected with the disease "[5]

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4 Loc cit p 188
5 Loc cit p 209

This conclusion has now to be considerably modified and amended when viewed in the light of the results obtained in the further experiments carried out during the present year

If a first or second subculture of the organism of contagious pleuro-pneumonia is used in an agglutination test with the serum of an animal known to be affected with contagious pleuro-pneumonia agglutination of the culture cannot be observed macroscopically at any time up to 40 hours after mixing the culture and serum together This fact has been repeatedly established by experiments conducted by the writer, and it was upon the results of those experiments that the above quoted conclusion was arrived at Further experimentation has demonstrated, however, that agglutination of a culture of the organism of contagious pleuro pneumonia by such a serum will occur, provided the culture used is *an old laboratory strain which has been subjected to repeated cultivation through several generations of subcultures,* the subcultures being made at intervals of from six to eight days

If for instance, an eighteenth or twentieth subculture, six to eight days old, is taken, and to it is added various dilutions of a known *positive* serum, agglutination and sedimentation of the culture will occur, and the supernatent fluid will lose its opalescence and become clear In the lower dilutions agglutination can also be observed with the same culture and a known *negative* serum, but, while agglutination takes place with a known positive serum in a dilution as high as 1 in 400, which dilution contains only 0 005 c c of pure serum, no dilution of a known negative serum higher than 1 in 80, which dilution contains 0 025 c c of pure serum, has been found capable of producing agglutination of the same amount of culture Thus there is a considerable difference in the end point values of positive and negative sera respectively, the difference being sufficiently great to preclude any possibility of errors in reading and recording the results of the reactions

The agglutination reaction in contagious pleuro-pneumonia *proceeds slowly* at incubator temperature, and apparently it is complete only after 48 hours in the incubator at 37°C After 24 hours' incubation little if any, agglutination is apparent with any dilution from 1 in 20 upwards of a known positive serum taken from an acute case of contagious pleuro-pneumonia, whereas after 48 hours, marked agglutination can usually be observed in a dilution of 1 in 400 or even higher

Attempts to expedite the reaction by heating the tubes in a water bath at various temperatures between 45°C and 55°C have not been successful, and the reactions obtained after incubation at such temperatures have not been so satisfactory, even at the end of 48 hours, as the reactions obtained with the same sera heated at 37°C Incubation for 48 hours at room temperature does not give as satisfactory results as incubation for 48 hours at 37°C

To prevent the growth of contaminating micro-organisms in the tubes during the 48 hours' incubation period required for the test, carbol saline solution was used as the diluting fluid This solution, which consists of 0 5 per cent carbolic acid in 0 9 per cent saline solution, has been found to be effective for the purpose intended, while at the same time it does not appear to exert any unfavourable action in the test

The cultures used in these macroscopic agglutination tests were cultures of the organism of contagious pleuro-pneumonia, grown in Martin's broth ox serum [6] (Reaction PH—8 4 approximately) and subcultured every 7 8 days, until at least the eighteenth subculture stage had been reached Each subculture at the time it was used in a test was from six to eight days old In each test the culture used was a live culture which showed a uniform though faint opalescence

One c c of culture (which quantity was taken as the standard amount) was measured into each of a series of agglutination tubes To each tube there was added a graded quantity of serum diluted with carbol saline so that the combined amounts of serum and carbol saline in each tube was equal to the amount of culture contained in the same tube Each tube therefore contained 2 c c s of fluid

In this manner, serum dilutions of 1 in 20, 1 in 40, 1 in 80, 1 in 100, 1 in 133, 1 in 200, and 1 in 400 were prepared and tested

The following table will explain the method of setting up the test —

Tube	Culture	Saline	Serum	Contents	Dilution
1	1c c	9	1	2c c	1 in 20
2	1c c	95	05	2c c	1 in 40
3	1c.c	975	025	2c c	1 in 80
4	1c c	98	02	2c c	1 in 100
5	1c c	985	015	2c c	1 in 133
6	1c c	99	01	2c c	1 in 200
7	1c c	995	005	2c c	1 in 400
*8	—	1 9	1	2c.c	—
*9	1c c	1c c	—	2c c	—

6 Martin's peptone broth to which has been added 1 5 per cent fresh unheated ox serum sterilised by filtration

* Controls

Twenty-three different sera obtained from animals affected with pulmonary lesions of contagious pleuro-pneumonia, the presence of the disease being verified by post-mortem examination at the time that the blood samples were taken, have been submitted to agglutination tests set up in the above manner, and in each instance marked agglutination has been the result

On comparing the results of the agglutination tests of these 23 positive sera with the post-mortem findings of the animals supplying them, it has been found that the more acute cases of contagious pleuro-pneumonia yield a serum which has a higher agglutination titre than that from cases in which the disease has become chronic and where encapsulation of the lung lesion has taken place more or less completely Even in these latter chronic cases in no instance in this series of tests had there been failure to produce agglutination in dilutions of 1 in 133 In the more acute cases, with one exception, agglutination occurred in dilutions of 1 in 400, while in two such cases agglutination occurred in dilutions of 1 in 750 The one exception referred to above was Number 143, the serum of an animal affected with the disease in an acute form, but which serum had a final agglutination titre of 1 in 133 only It would therefore appear that a serum with a high agglutination titre points to an acute infection, but, in view of the one exception quoted above this cannot be stated as an invariable fact, but only as a general rule

In addition to the agglutination tests of 23 different known positive sera, tests have been made with 18 different sera obtained from animals which were found on post-mortem examination to be free from lesions of contagious pleuro-pneumonia These known negative sera all showed agglutination in dilutions of 1 in 20 Thirteen of them showed agglutination in dilutions of 1 in 40, while five of them showed slight agglutination in dilutions of 1 in 80 None of them showed any recognisable agglutination in dilutions of 1 in 100

A complete list of the sera tested and a table of the reactions obtained with each is appended, together with an indication of the post mortem findings on slaughter of the animals supplying the test sera

TUBE

Serum Number	1	2	3	4	5	6	7	8	9	Animal Supplying Serum Showed on Post mortem
105	+++	+++	++	++	++	++	+	No change	No change	Acute infection
106	++	++	++	++	++	++	++	,,	,,	Acute infection
107	+	++	+++	++	++	++	++	,,	,,	Acute infection
108	++	++	++	++	++	+	S	,,	,,	Acute infection
109	++	+	−	−		−	−	,,	,,	No lesions
110	+	S	−	−	−	−	−	,,	,,	No lesions
111	++	+	S	−	−	−	−	,,	,,	No lesions
112	++	++	-	+	+	S	−	,,	,,	Chronic infection
113	++	+	−	−	−	−	−	,,	,,	No lesions
114	+	S	−	−	−	−	−	,,	,,	No lesions
115	++	++	++	+	+	+	S	,,	,,	Acute infection
116	++	++	−	+	S	S	−	,,	,,	Chronic infection
117	S	−	−	−	−	−	−	,,	,,	No lesions
118	++	+	+	+	+	+	+	,,	,,	Acute infection
119	++	++	++	++	++	++	++	,,	,,	Acute infection
120	+	+	++	++	+	+	S	,,	,,	Acute infection
121	+	S	−	−	−	−	−	,,	,,	No lesions
122	++	++	+	−	−	−	−	,,	,,	No lesions
123	+	S	−	−	−	−	−	,,	,,	No lesions
124	S	−	−	−	−	−	−	,,	,,	No lesions
125	S	−	−	−	−	−	−	,,	,,	No lesions
126	+	S	−	−	−	−	−	,,	,,	No lesions

+++ = Agglutination and sedimentation of agglutinated organisms with complete naked eye clearing of the supernatent fluid
++ = Agglutination with well defined deposit, fluid nearly clear
+ = Marked flocculent agglutination and some sedimentation, fluid not clear
S = Slight agglutination deposit, fluid not clear
− = No naked eye trace of agglutination or clearing of fluid

TUBE

Serum Number	1	2	3	4	5	6	7	8	9	Animal Supplying Serum Showed on Post-mortem
127	++	++	++	++	+	+	+	No change	No change	Acute infection
128	+++	+++	+++	+++	++	++	++	,,	,,	Acute infection
129	++	++	++	++	++	+	+	,,	,,	Acute infection
130	++	++	+	+	+	S	—	,,	,,	Chronic infection
131	++	++	++	++	++	++	++	,,	,,	Acute infection
132	+++	+++	+++	+++	+++	+++	++	,,	,,	Acute infection
133	++	++	++	—	+	S	S	,,	,,	Acute infection
134	++	+	S	—	—	—	—	,,	,,	No lesions
135	S	—	—	—	—	—	—	,,	,,	No lesions
136	++	++	++	++	++	—+	++	,,	,,	Acute infection
137	++	++	++	+	+	S	—	,,	,,	Chronic infection
138	++	++	++	++	+	+	+	,,	,,	Chronic infection
139	+++	+++	++	++	++	—+	+—	,,	,,	Acute infection
140	+	—	—	—	—	—	—	,,	,,	No lesions
141	++	+	S	—	—	—	—	,,	,,	No lesions
142	+	S	—	—	—	—	—	,,	,,	No lesions
143	++	++	++	—+	+	—	—	,,	,,	Acute infection
144	+	S	S	—	—	—	—	,,	,,	No lesions
145	++	++	++	++	—+	++	+	,,	,,	Acute infection

+++ = Agglutination and sedimentation of agglutinated organisms with complete naked eye clearing of the supernatant fluid
++ = Agglutination with well defined deposit, fluid nearly clear
+ = Marked flocculent agglutination and some sedimentation, fluid not clear
S = Slight agglutination deposit, fluid not clear
— = No naked eye trace of agglutination or clearing of fluid

Compared with the complement fixation test in contagious pleuro-pneumonia, the agglutination test appears to possess a reliability and accuracy in reaction which is at least equal to, if not greater, than that of complement fixation

Agglutination reactions are not affected by the presence of conglutinin in bovine sera, whereas that same substance is always liable to affect the result of complement fixation reactions, and may be responsible for a large number of false reactions

To prevent the action of conglutinin interfering with the accuracy of the complement fixation test, an exceedingly intricate and laborious technique has to be followed in each detail by the operator In these successive manipulations the possibility of personal error on the part of the operator is very largely increased By reason of its simpler technique the agglutination test is not so liable to errors on the part of the worker

So far as it has been tested the agglutination reaction in contagious pleuro-pneumonia appears to provide us with a simple means for determining the presence of the disease, at least in the acute form, in the living animal Although the number of positive sera tested is not very large, being only 18 from animals in which the disease was acute and five from animals in which the disease was chronic, it would appear that the possibility of error in acute cases of the disease is not very great owing to the well marked differences in the end point values of sera taken from acute cases and those taken from animals free from the disease In the case of animals in which the disease is chronic, diagnosis by means of the agglutination test does not appear to be so certain, although there is still a fairly wide difference in the end point values of such sera when compared with the values of known negative sera

Application of the test to a large number of cases showing chronic lesions is necessary to justify any firm conclusions on this point

Specificity of the Complement Fixation and Agglutination Reactions in Contagious Pleuro-Pneumonia

Since the publication of the results of the examination of 63 different serum samples for complement fixation and the subsequent post-mortem findings when the animals were slaughtered, experiments have been conducted to ascertain whether, when a positive complement fixation result is obtained, the reac-

tion has been induced solely by the fact that the animal is affected with contagious pleuro pneumonia In one of the cases quoted a positive complement fixation result was obtained but no lesions of the disease could be discovered in the lungs when the animal supplying the test serum was subsequently submitted to a post mortem examination That the reaction might be *a group reaction for filterable viruses in general* and not absolutely specific for the filterable virus causing contagious pleuro pneumonia in cattle seemed possible Of the diseases in cattle due to filterable viruses only two e g contagious pleuro pneumonia and cow pox (Variola) are present in Australia so that tests for comparative purposes have of necessity been confined to tests of sera from animals known to be affected with cow pox

Samples of sera taken from a cow at the Veterinary School which was affected with extensive cow pox vesicles and pustules on the mammary gland were tested and were found to give positive complement fixation results with the contagious pleuro pneumonia antigen The possibility of the same animal being affected with contagious pleuro pneumonia as well as with cow pox was negatived by the general appearance of the animal and her previous history

Through the courtesy of Dr W J Penfold Director of the Commonwealth Serum Laboratories I have been able to obtain serum samples from 11 calves which had been vaccinated with the virus of cow pox in the manufacture of vaccine lymph for human vaccination Each of the calves had given a typical reaction to the vaccination

On submitting the samples to complement fixation tests with the contagious pleuro pneumonia antigen it has been found that they all show some ability to inhibit haemolysis

It is apparent therefore that in carrying out tests with sera from an unknown source the serum of an animal affected only with cow pox may cause sufficient inhibition of haemolysis in a complement fixation test for contagious pleuro pneumonia to give rise to the assumption on the part of the person carrying out the test that the animal supplying the test serum is affected with contagious pleuro pneumonia

Serum from the cow affected with cow pox at the Veterinary School which serum gave a positive complement fixation reaction and the three samples of calf serum which showed the greatest amount of inhibition of haemolysis in the complement fixation

test, were next submitted to the macroscopic agglutination test They are numbers 111, 121, 122, and 123 respectively in the chart of agglutination reactions forming portion of this paper. Their reactions to the agglutination test were negative in each case, although with numbers 111 and 122, agglutination took place in dilutions as high as 1 in 80

Literature Cited

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Art XX—High Frequency Spectra—K Series of Platinum

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(With Text Figs 1A 1B, and 2)

[Read 8th December 1921]

Introduction

The purpose of this paper is to describe a precise method of measuring the wave lengths of the high frequency spectrum of platinum

The method employed is one in which a rotating crystal spectrometer is used, and the platinum lines, together with those of tungsten are recorded on the same film The wave lengths of the platinum lines are deduced by inter and extra-polation from the tungsten lines the wave lengths of which are known with great accuracy, having been measured recently with great precision by Siegbahn[1] and by Duane and Stenstrom[2]

The investigation of the K lines of platinum, in common with those of other heavy elements, is beset with certain difficulties, which have prevented the spectra of these elements being determined

In order to excite efficiently the K spectrum of an element of high atomic number, it is necessary to use the substance as target in an X-ray tube A very high potential difference must then be applied to the tube, since a minimum pressure of 78,000 volt is required to obtain the K series of platinum Under such high pressures there is always the risk that the tube will fail Again, a very high vacuum must be present in the tube In the case of a gas filled tube this became a source of considerable difficulty, for, even when the requisite vacuum is obtained, the tube becomes very uncertain in operation, and, under the very best conditions, only a small current can be passed through the tube In consequence, the X-rays produced possess

1 Phil Mag XXXVIII Nov 1919
2 Proc Nat Acad Sci VI 1920 p 477

but a small amount of energy and have very little photographic effect It is thus essential to have long exposures

The photography of the lines is complicated still further by the photographic fog produced by the rays scattered by various parts of the apparatus (slits crystal etc) Since the lines occur on the film very close to where the direct rays fall the scattered rays are most intense just at the region where the lines are to be observed

The one heavy element the high frequency spectrum of which has been carefully investigated is tungsten Since this element has been used as the material of the target in the Coolidge type of tube it is a comparatively easy matter to excite its K series spectrum As there was no Coolidge type of tube with a platinum target available for this research a gas filled tube made by Gundelach was used

The K series of platinum has been measured once previously —by Lilienfeld and Seeman[3] who employed a Lilienfeld tube with a target of platinum iridium The values obtained by these authors are given in Table II

The Spectrometer

The whole of X ray spectroscopy is based on the fact that a crystal acts as a space grating to X rays W L Bragg[4] showed that if a parallel beam of X rays of wave length λ was directed on a crystal face at an angle θ so that $\lambda = 2d \sin \theta$ there would be an interference maximum at an angle θ and other maxima at values of θ given by $n\lambda = 2d \sin \theta$ n is here an integer and d is the lattice constant of the crystal i e the distance between successive planes of atoms parallel to the reflecting face If then it is desired to resolve a beam of X rays into its component parts it is necessary that the crystal should be placed at different angles with respect to the incident beam This is done most efficiently by rotating the crystal slowly and uniformly

Further W H Bragg[5] established that if a diverging beam of X rays issued from a narrow slit S_1 (fig 1(b)) and fell on a crystal face which was rotating about a point O (axis of rotation) and if a photographic film was placed round the circle

[3] Phy Zeit XIX 1918 p 269
[4] X Rays and Crystal Structure p 16
[5] X Rays and Crystal Structure p 31

FF′, which has O as centre, and OS_1 as radius, all the X-rays of a certain wave length λ would be reflected to a particular vertical line on the film. If there is present in the incident beam X-rays of a definite wave length, carrying more energy than those of adjacent longer and shorter wave legths, then its presence will be shown by a line on the film

An additional advantage of a rotating crystal is that it gives much sharper lines than a stationary one, since the effect on the lines of surface defects of the crystal is thus considerably lessened

No spectrometer being available, a Dancer theodolite was modified to have the movements of a spectrometer, and to fulfil the requirements of the focussing condition It may be mentioned that a theodolite can be adapted to form a spectrometer, which is both accurate and convenient

The circle carrying the scale was fixed by shrinking a brass ring on to its under surface at AA′ (fig 1a) This ring was supported by a tripod mounted on the ring BB′, through which passed three levelling screws bearing on a stone table The crystal holder was mounted on the vernier circle at D The film holder was carried by an arm which screwed into the theodolite at E Both crystal holder and film holder turned on conical bearings The slits S_1 and S_2 were supported by a brass tube which screwed into the ring BB′

The *crystal* was a large calcite one The reflecting face (5 cm x 2 cm) was a ground cleavage one As W I Bragg James and Bosanquet[6] have shown ground faces are more efficient reflectors than natural cleavage faces

The *crystal holder* was so designed that the reflecting face of the crystal could be made vertical, and could be brought into the axis of rotation of the spectrometer

The *film holder* was cut from a brass ring, the inside edge of which was accurately turned, its radius being 10 001 ± 001 cm The film, in its paper casette, was tightly pressed against this by means of two curved strips of red fibre and clamping screws

Slits —The slit S_1, the tube slit, was made of an alloy of lead and antimony (75 per cent lead), such an alloy being more durable than pure lead The inside faces of this slit were carefully ground, and the slit width could be adjusted by a screw to 0 005 mm The slit S_2 was made of lead, and was carried by the

6 Phil Mag XLI 1921 p 309

same holder as S_1. This holder was constructed to allow the following adjustments: (a) It could be moved towards the axis of rotation of the spectrometer; (b) S_1 could be made vertical;

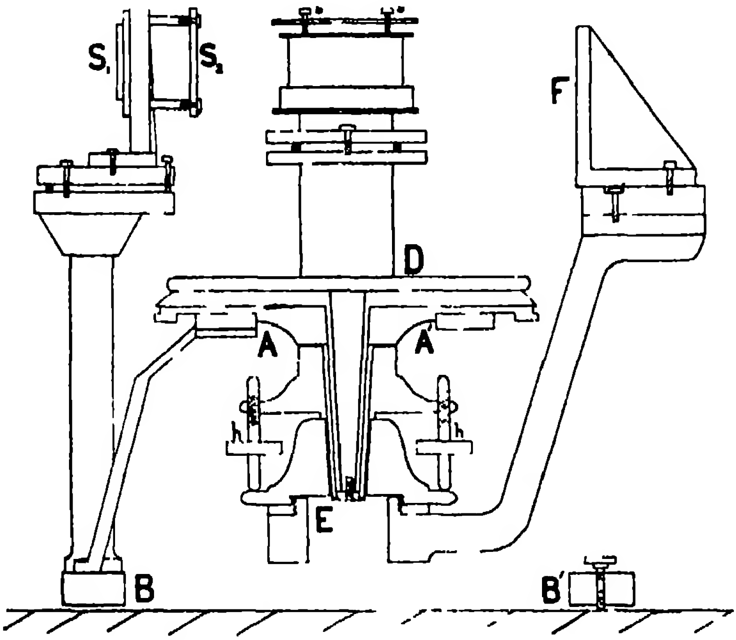

FIGURE 1A

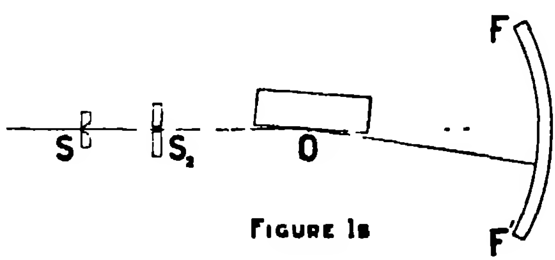

FIGURE 1B

DIAGRAM OF THE SPECTROMETER

(c) the line joining the centres of the slits could be made to pass through the axis of rotation.

Rotation Apparatus.—The vernier circle was rotated by means of a tangent screw. By means of a reduction gear, this was turned at 1/10,000th of the speed of a small motor. In the experiments, the rate of rotation of the crystal was about 2° per hour.

Adjustments

The following are the essential requirements of a spectrometer of this type The tube slit, the axis of rotation of the spectrometer and the axis of the film holder should all be parallel, and, in this case, vertical, the tube slit and the curved portion of the film holder should be equidistant from the axis of rotation, the ground face of the crystal should be so placed that the axis of rotation lies in it the central ray from the ' focal spot " of the target should pass through the centres of the slits S_1 and S_2, through the axis of rotation, and at right angles to it

After the vernier circle had been levelled, the axis of rotation was found by so placing a vertical needle that its point, when viewed from above by a long focus microscope, remained stationary when the circle was rotated The tube slit was then adjusted 10 cm distant from the needle point, and was placed vertical The axis of the film holder was next made vertical by means of the screws *h* (fig 1a), and with the use of a centre tester, it was brought into coincidence with the axis of rotation of the spectrometer

The crystal face was brought into the axis of rotation by so placing it, that the position of the edge, as viewed in a low power miscroscope with its axis vertical, was in the same position both before and after the crystal had been rotated through 180° The adjustment was carried out finally so that the distance of the face from the axis of rotation was less than 01 mm

An optical method was used to test if the crystal face was vertical By illuminating the slit S_1 it was possible to view, in a telescope, both the slit itself and its image reflected in the crystal face When the face was vertical, the slit and its image were parallel for all positions of the crystal

The slit S_1 was then so turned, and the crystal face was so placed that the light from the slit passed along the crystal face both before and after the crystal was rotated through 180° This adjustment was carried out by means of a telescope, and it ensured that the ray from the centre of S_1 passed through the axis of rotation The sides of the slit S_2 were then placed symmetrically with respect to those of S_1 In the experiments the widths of the slits were S_1 0 08 to 0 1 mm , S_2, 0 6 mm

The focal spots on the targets of both tubes were clearly marked The focal spot in the case of the Coolidge tube was illu-

minated by lighting the filament, but for the Gundelach tube, light from a lamp was focussed on the target The focal spot was viewed through a horizontal telescope, placed at the same height above the table as the centre of the crystal face, and the necessary adjustments for the central ray were easily carried out

In the experiments described below it was necessary to adjust the focal spot of the Coolidge tube when it was not possible to use a telescope In this case a mirror was used, and the images of the focus, slit and crystal face were viewed from above

Experiment

Tube—The target of the Gundelach tube consisted of a platinum button attached to a stout copper rod on the external end of which was a brass radiator The potential difference applied to the tube was produced by a Snook Victor high tension rectifier

At the beginning of the research, the tube was too soft to excite the K series of platinum The maximum pressure that could be applied to the tube was 60 000 volt If the switches on the high tension rectifier were turned to increase the pressure, the only result was an increase in the current passing through the tube It was found however that by keeping the current low —less than 0 5 m a —that the tube gradually hardened After a fortnight's running, for several hours a day, a pressure of 85 000 volt could be applied to the tube It was found difficult to maintain this potential difference because fluctuations in the current became very big, and, with the increase in current there was the consequent drop in pressure

After a considerable amount of experiment the following procedure was adopted The tube was allowed to harden, so that there was practically no current, when a pressure of 95,000 volt was applied Then, to begin an experiment the tube was slightly softened, so that a current of 0 6 m a was obtained at 85 000 volt If the current became less the pressure was raised and usually this gave an increase in current The usual experience was however that the current with the attendant fluctuations increased after about 15 min, so that the corresponding falls in pressure were less than 80 000 volt This was probably due to the target as it became heated giving off occluded gas The pressure was then cut off from the tube for between

5 and 10 min, and, at the end of this time, the tube would be again in a condition suitable for use To obtain lines sufficiently intense to measure, an exposure of 10,800 milliampere sec was necessary Since the average current through the tube was between 7 and 8 m a, such an exposure required an experiment of at least six hours The greater intensity of the radiation from a Coolidge tube was shown by the fact that more intense lines were obtainable from it in 5 min.

The *film used* was Eastman Dulpli-tized (photographic emulsion on both sides) which was placed between two Patterson intensifying screens It has been stated that sharply defined lines cannot be obtained when intensifying screens are used However, quite satisfactory lines were obtained since under these conditions the α doublet of tungsten was resolved with a slit width of 0 12 mm One great advantage of the doubly coated film is its rigidity—there is no tendency to buckle during drying Had intensifying screens not been used, the exposures would have been so long as to be practically impossible

Protection from Scattered Radiation—A sheet of aluminium 0 6 mm thick was placed in front of the film to absorb the soft scattered radiation In addition the rays reflected from the crystal were made to pass along a channel the sides of which were constructed of lead 3 mm thick This channel converged on all sides towards the crystal where its opening was a rectangle 2 cm x 6 mm This was large enough to allow both the direct rays and the lines to fall on the film

Reference Lines—The Pt lines were photographed on the top half of each film, the lower part being covered with a lead screen The Coolidge tube was then substituted for the Gundelach, and the W lines were photographed on the lower portion of the film Since the film was held by the red fibre strips (vide page 198), there was no opportunity for it to slip during an experiment The lines appeared as shown in figure 2 It will be seen that the α doublet of platinum falls between the α and β lines of tungsten (The thickness of lines in the figure indicates relative intensities)

Measurement of Lines—The film was projected by a lantern, and a magnification up to 10 was obtained The lines on each film were measured at three different magnifications, and the mean of the values so obtained was taken as the wave lengths of the lines given by the film.

A dividing engine, with a very accurate screw, was adapted for measuring the distance between the lines. A vertical board was carried by the moving platform of this engine. Two vertical lines 1.5.mm. apart were drawn on this board, and each line on

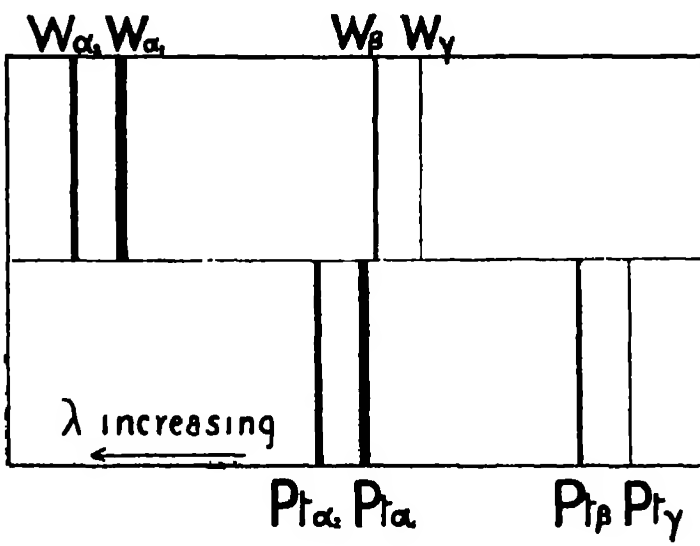

FIGURE 2

the film was brought in turn exactly between these lines, and the reading of the engine noted. Table I. shows a set of such readings.

TABLE I. (Distances in mm.).

—	W α_2.	W.α_1.	Pt α_2	Pt α_1.	W β.	W.γ.	Pt.β.	Pt.γ
	0	1·13	5 87	7·10	7·25	8 51	12 46	13 60
	0	1·18	5 84	7·14	7 30	8 48	12·23	13 46
	0	1·15	5 90	7 18	7 29	8 50	12 38	13 47
	0	1·14	5 90	7 10	7 29	8 42	12 36	13 41
	0	1 15	5 88	7 22	7 33	8 41	12 29	13 50
Mean -	0	1·15	5·878	7·144	7 296	8 472	12 34	13 50

It will be seen that, for the fainter lines, e.g., the β and γ lines of Pt., there is much greater variation in setting than for the more intense lines. To evaluate the wave lengths the mean of

Siegbahn's and Duane and Stenstrom's values were assumed. These are as follow:—

$$\lambda \textit{ for } W\alpha_2 = \cdot 21347 \times 10^{-8}\text{cm}$$
$$W\alpha_1 = \cdot 20873 \quad ,, \quad ,,$$
$$W\beta = \cdot 18428 \quad ,, \quad ,,$$

The value in Angstrom units per mm of the projection was found from the mean of the distances between the $W\alpha_2$ and $W\beta$ lines, and the $W\alpha_1$ and $W\beta$ lines. The wave lengths of the other lines were then calculated proportionally. As a test of the accuracy of the method, the value of the wave length of the $W\gamma$ line was obtained The mean value is given below. The mean of the values obtained for this line by the above authors is .17921.A.U.

The method employed rests on the assumption that the wave lengths of the lines on the film are proportional to the angles at which they are reflected at the crystal. According to Bragg's formula, $\lambda = 2d \sin \theta$, these wave lengths are proportional to the sine of the angle. No error was introduced in the values given below since θ for $K\alpha_2 = 2°$ (*q.p.*) and θ for $Pt.\gamma = 1°30'$ (*q.p.*)

Results and Discussion.

In Table II. are given the values obtained. The wave lengths were calculated to five decimal places, and the final values are given to four places, with the probable error.

Table II (λ in Angstrom Units).
Wave Lengths of K Series of Platinum

Film No.	$Pt.\alpha_2$.	$Pt.\alpha_1$.	$Pt\ \beta$.	$Pt.\gamma$.	$W\ \gamma$.
P.14	·18939	·18496	16455	15955	·17952
P.15	·18926	18536	16427	15968	·17905
P 16	·18998	·18502	·16429	·15942	·17978
Mean - -	18954	18511	16437	·15955	·17948
Final - -	·1895±2	·1851±1	1644±2	·1596±2	1794±2
Lilienfeld and Seeman	·1907	·1853	·1642	·1593	—

In the last line of the table the values obtained by Lilienfeld and Seeman are inserted for comparison. The agreement is good

except for the Pt α_2 line. The apparent discrepancy can be explained by the fact that these authors were unable to distinguish between the Pt α_2 line and the Ir.α_1 line. The writer has found that if the K spectra of Pt. and W are photographed on the same portion of a film, it is impossible to recognise as separate lines, the Wβ (λ=·1843) and Pt.α_1(λ=·1851)

Theory of Lines.—The K series of an element is excited when an electron is ejected from the K ring of the atom. If this electron is replaced from the L ring of the atom, the energy so freed gives rise to the α_1 line. If it is replaced from an electron from the L′ ring (an elliptical orbit), the α_2 line is excited. Replacements from the M and N rings give rise to the β and γ lines respectively.

Moseley's formula, $\frac{v}{R}=(N-1)^2(1/1^2-1/2^2)$, for the wave number v of the Kα_1 line, which accurately represents the observed values for low values of N, fails for elements of higher-atomic number. (R is here Rydberg's constant, N the atomic number of the element.) The value of the wave length of the Pt α_1 line from this formula would be .2049 x 10^{-8} cm.

Sommerfeld has developed a formula for the wave number $v(=1/\lambda)$, by considering the effective nuclear charge for the K and L rings as (N−1.6) and (N−3.5) resp. and by taking into account the relative masses of the electrons in consequence of their velocity. The formula is:—

$$v/R=\frac{2}{a^2}\left(\sqrt{1-\frac{a^2}{4}(N-3{\cdot}5)^2}-\sqrt{1-a^2(N-1{\cdot}6)^2}\right)$$

where $a=\frac{2\pi e^2}{ch}$ e, c, h being the charge on the electron, the velocity of light and Planck's constant respectively. Hence $a^2=5.3088\times10^{-5}$.

This formula gives λ for Kα_1 of Pt.=·1837 × $10.^{-8}$ cm.

A formula due to Kroo and Sommerfeld fits the observed value more accurately still. In this, before the passage of the atom, which gives rise to the Kα_1 line, the K ring is considered as a 1 quantum ring with 2 electrons, the L ring as a 2 quanta ring with 9 electrons. After the passage of the electron, the K ring is a 1 quantum ring with 3 electrons, and the L ring as a 2 quanta ring with 8 electrons. By calculating the energy

difference between the two configurations, the following formula is obtained —

$$\frac{v}{R}=\frac{2(k-1)}{a^2}\sqrt{1-a^2F_1}+\frac{2(l+1)}{a^2}\sqrt{1-a^2F_2}-\frac{2k}{a^2}\sqrt{1-a^2F_3}$$
$$-\frac{2l}{a^2}\sqrt{1-a^2F_4}$$

where $k=3$, $l=8$, $F_1=(N-S_{k+1})^2$, $F_2=\frac{1}{4}(N-k+1-S_{l+1})^2$, $F_3=(N-S_k)^2$,
$F_4=\frac{1}{4}(N-k-S_l)^2$

and the S terms are obtained from

$$S_p=\frac{1}{4}\sum_{1}^{i=p-1}\frac{1}{\sin i\frac{\pi}{p}}$$

For Pt this gives the values of $\lambda K\alpha_1$ as 1841×10^{8} cm The agreement with the observed value is remarkable, as the formula is a rational relation This lends additional support to the Bohr-Sommerfeld theory of the atom

Sommerfeld has also obtained the following formula for the difference in wave number Δv for the lines of the $K\alpha$ doublet —

$$\frac{\Delta v}{(N-3\ 5)^4}=\Delta v_H\left[1+\frac{5a^2}{2}\frac{(N-3\ 5)^2}{2^2}+\frac{53a^4}{8}\frac{(N-3\ 5)^4}{2^4}\right]$$

where Δv_H=frequency difference for hydrogen$=\frac{Ra^2}{2^4}$

From the results of the experiment, given in Table II $\Delta v\times10^{8}$ $=126\pm008$, while the above formula gives $\Delta v\times10^{8}=135\pm002$

It will be seen that the agreement is again fairly good

In conclusion, the author wishes to express his indebtedness to Prof T H Laby M A Sc D F Inst P for his invaluable guidance and advice throughout the whole of the research, and in the writing of this paper

The Gundelach tube used in these experiments was presented to the Natural Philosophy Department, Melbourne University by W Watson and Sons

[Proc Roy Soc Victoria 34 (N S) Part II 1922]

Art XXI —*Contributions from the National Herbarium of Victoria — No.* 1

By J R TOVEY and P F MORRIS

(With 2 Text Figures)

(Communicated by Wm Laidlaw B Sc)

[Read 8th December 1921]

The present paper contains the descriptions of two species new to science both from Western Australian localities A new variety has also been established a native of the alpine regions of Victoria New South Wales and Tasmania Three foreign plants have been recorded for the first time, whilst the orchid *Corysanthes bicalcarata* a native of New South Wales Queensland and Tasmania has been added to the Victorian Flora In addition several new records of the regional distribution of native and introduced plants are given

It is proposed to continue these contributions as material becomes available and opportunity offers

Aponogeton distachyum Thunb "Cape Pond Lily" (Naiadaceae)

Stony Creek Lorne Victoria Rev A C F Gates November, 1921

This South African plant has escaped from cultivation and is now spreading in several parts of the above named creek where it will no doubt become naturalised

Bossiaea Laidlawiana sp nov (Leguminosae)

Frutex arbuscula concinna alta quindecim ad viginti pedes, rami tomentosi Folia longa dimidiam partem unciae lata circiter tres partes unciae adversa pedunculi breves serrata haud pungenter acuta aut alte sinuata eodem modo quo B Aquifolium Nonnulla foliorum superiorum hirsuta infra Flores soli, axillarii vexillum et alae flava carina purpurea flores in pediculis plerumque tam longi quam calyx bracteae interiores et bracteolae

persistentiores quam B Aquifolium Calyx longa unum ad unum et dimidium lignum, lobae duae superiores late truncatae tres inferiores breviores, sed acutae Vexillum ter tam longa quam

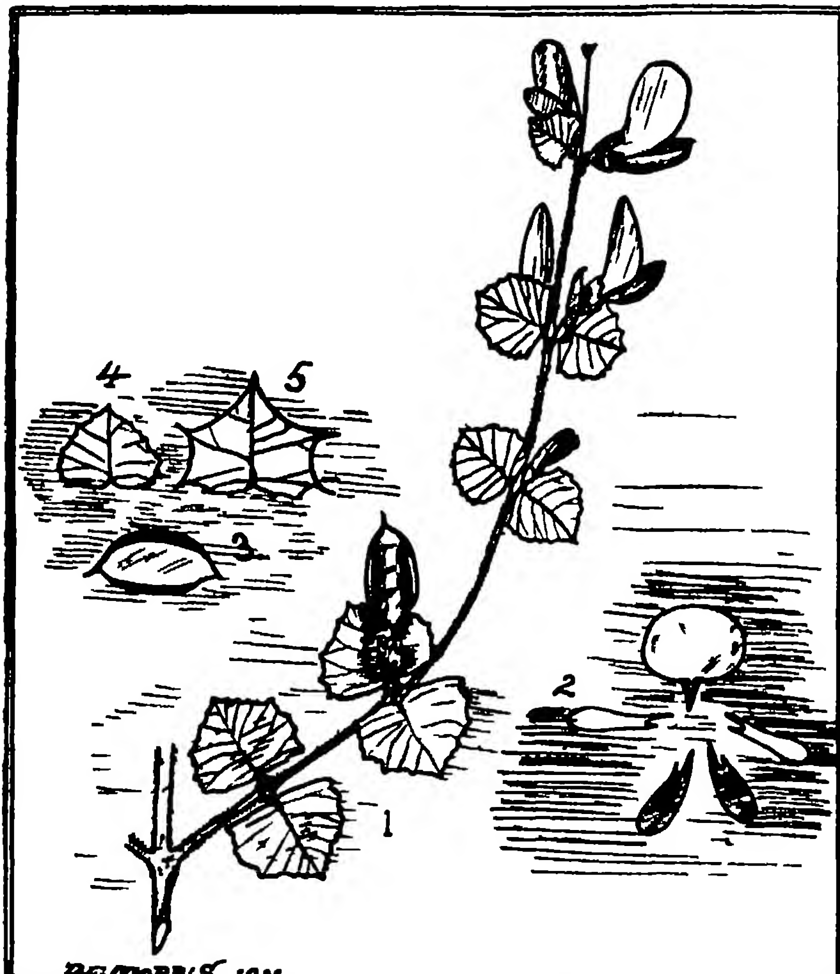

Fig 1 —Bossiaea Laidlawiana n sp
(1) Portion of plant in flower and fruit (2) Flower dissected
(3) Legume (4) Leaf (5) Leaf of B aquifolium

calyx, petala inferiora paulum breviora, ovarium cum tribus ovulis Legumen longa circiter tres partes unciae et lata unam partem unciae

An elegant shrub, 15 to 20 feet high, branches tomentose. Leaves half inch long, about three quarters inch broad opposite,

shortly pedunculate, serrated, not pungently pointed or deeply sinuate as in *B. Aquifolium.* Some of the upper leaves hairy beneath. Flowers, solitary, axillary, standard and wings yellow, keel purplish red; flowers on pedicels usually as long as the calyx. Inner bracts and bracteoles more persistent than B. Aquifolium. Calyx, 1-1½ lines long; lobes, two upper ones broadly truncate, lower 3 shorter, but pointed. Standard 3 times as long as calyx, lower petals slightly shorter. Ovary, 3 ovules. Pod about ¾ inch long, and ¼ inch broad.

Pemberton and Manjimup, Warren district, West Australia, Max Koch, No. 2244 Oct, Dec, 1918; Western Australia (in National Herbarium, Melbourne, without collector's name or precise locality).

Its nearest affinity is *B Aquifolium*, from which it differs in being a tomentose shrub of 15-20 feet, colour and size of flowers, shape of leaf, calyx and standard.

Named in honour of Wm. Laidlaw, B.Sc, Government Botanist for Victoria.

BROMUS TECTORUM, L. "Wall or Downy Brome-Grass" (Gramineae).

Parkville, near Melbourne, A. O'Brien, Nov, 1921.

This grass, a native of Europe and Asia, is introduced and widely spread in United States, America, where it is looked upon as a very objectionable grass, but it has not been previously recorded as growing wild in Victoria.

CALADENIA ANGUSTATA, Lindl. "Slender Caladenia" (Orchidaceae).

Hurst Bridge, Victoria, Miss S. Llewelyn, Oct, 1921.

A new locality in Victoria for this orchid.

CHORETRUM PENDULUM, sp. nov. (Santalaceae).

Pendens aut frutex arbuscula lacrimosa alta circiter sex pedes; folia redacta ad crustas minutas, satis persistentia, paulum curva ad apices acutas Rami inferiores interstincti aut striati; ramusculi angulares exacute. Flores parvi (sed maiores quam C. lateriflorum), soli, pedunculi breves, corolla alba. Flores sparsi et cum longioribus intervallis quam in C. lateriflorum; quisque flos circumplexus ovi forma pravis bracteis et bracteolis. Ovarium

inferius, stigma cum quinque lobis; fructus drupae aridae et flavae, et coronatae cum quinque lobis perianthialibus.

A pendant or weeping shrub about six feet high; leaves re-

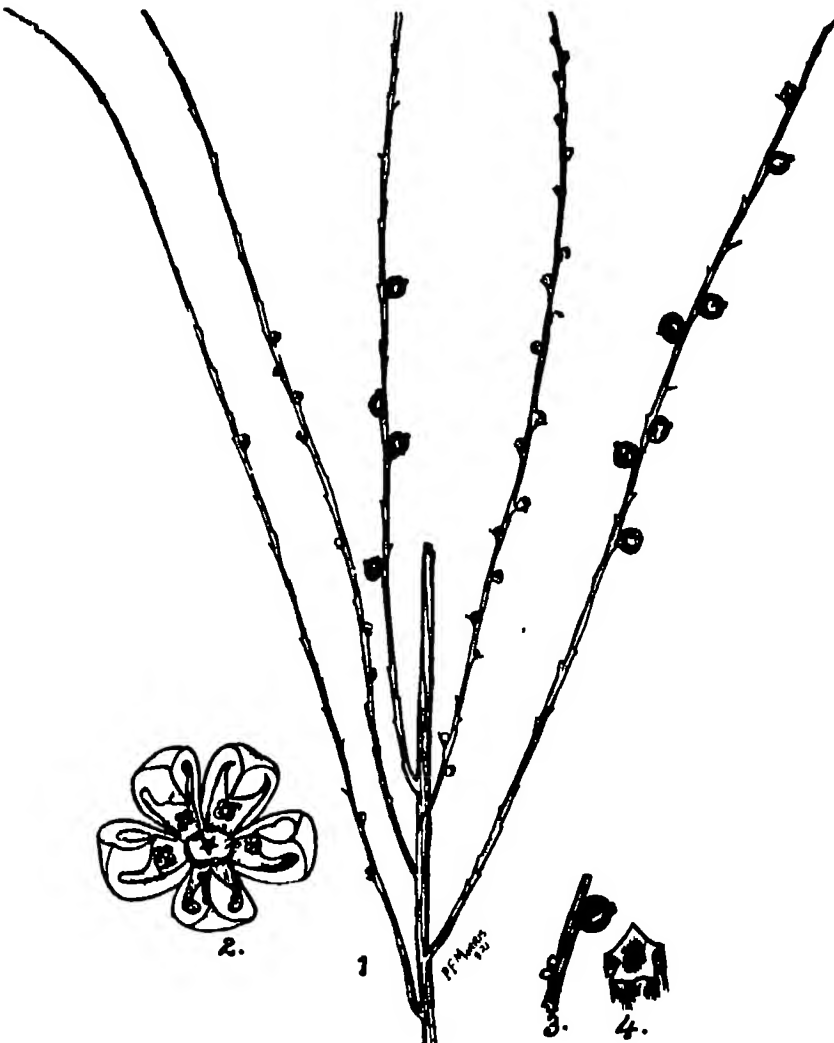

FIG. 2.—CHORETRUM PENDULUM, N.SP.
(1) Portion of plant in flower and in fruit. (2) Flower (enlarged).
(3) Fruit with bracts and bracteoles. (4) t s. of stem.

duced to minute scales, fairly persistent, slightly curved at the pointed tips. Lower branches streaked or grooved, the branchlets acutely angular. Flowers small (but larger than in the type of C. lateriflorum), solitary very shortly pedunculate, corolla

white Flowers scattered and further apart than in *C laterifl-florum*, each flower surrounded by small oval bracts and bracteoles Ovary inferior, stigma five lobed, fruit a dry globular drupe yellow, and crowned with five perianth lobes

Pemberton Warren district West Australia Max Koch, No 2409 (Oct, 1919), and No 2537 (Jan, 1921)

Its nearest affinity is *C lateriflorum* from which it differs in having larger flowers height the shape of branches, pendulous habit fruit and stigma lobes, the bracts and bracteoles being more rounded, and the fruit on a shorter peduncle

Mr Spencer le Moore, of the British Museum to whom a specimen was submitted for comparison with Brown's type of *C lateriflorum* says 'We received this some three years ago from Dr Stoward who met with it in the 'Albany District' The specimens were in fruit only and I was unable to name them Now that the flowers have been found there is apparently no doubt as to the plant's novelty "

CORYSANTHES BICALCARATA R Br (Orchidaceae)

Healesville Victoria Miss D Coleman July 1921

Previously recorded from New South Wales Queensland and Tasmania

ERAGROSTIS CURVULA Nees var VALIDA Stapf
African Love Grass '

Government House Domain Melbourne Miss A M Tovey, Nov 1921

This South African grass was previously recorded from Drouin Gippsland The grass becomes too wiry to be of much use for fodder

EURYOPS ABROTANIFOLIUS D C " Southern wood leaf Euryops "
(Compositae)

Near Menzies' Creek Paradise Victoria J W Audas August, 1921

This South African plant may be regarded as an exotic not yet sufficiently established to be considered naturalised

HELICHRYSUM ROSMARINIFOLIUM, Less var LEDIFOLIUM comb nov (Syn Helichrysum ledifolium, Benth) Compositae

Victoria Mt Hotham, C Walter (no date), Mt Hotham, 6000 feet, A J Tadgell Dec, 1914, also found in New South

Wales and Tasmania. The branches of this variety are rather stouter, the leaves are more crowded and thicker, the flower heads are larger, but otherwise the inflorescence, involucres, florets, achenes and pappus quite as in *H rosmarinifolium.*

LUZULA CAMPESTRIS D C, var AUSTRALASICA, Buch (syn L Oldfieldii, Hook, f) (Juncaceae)

Bennison's Plain, Gippsland, A W Howitt, 1887, Hawkesdale, H B Williamson May, 1899, Lorne Rev A C F Gates, Nov, 1921

This variety, a native of New South Wales and Tasmania, has now to be recorded for Victoria

MELALEUCA ERICIFOLIA Sm "Swamp Paper-Bark" (Myrtaceae)

Epsom, near Bendigo, D J Paton Nov, 1921

A new locality in Victoria for this plant

MOENCHIA ERECTA Sm "Upright Moenchia" (Caryophyllaceae)

This plant, a native of Europe, was recorded under the name of *Cerastium quaternellum*, Fenzl in Vict Nat X, p 145 (1893) as a naturalised alien in Victoria The genus *Moenchia* was then placed as a subgenus of *Cerastium* but as *Moenchia* is now considered to be a valid genus the specimens hitherto known in Victoria as *Cerastium quaternellum* have to be changed to *Moenchia erecta,* Sm

This plant is also found in Tasmania

NOTHOLAENA DISTANS R Br "Bristly Cloak Fern" (Filices)

Granite Rocks on Big Hill, near Bendigo David J Paton, January and May, 1921

A new locality in Victoria for this fern

ZIERIA ASPALATHOIDES, A Cunn "Hairy Zieria" (Rutaceae)

Mt Tarrangower, about 1300 feet, Maldon, Victoria, Rev W C Tippett, Oct, 1921

A new locality for this plant It was previously recorded from the Grampians, A Cunningham, and Barren ridges near Goulburn River, F v Mueller It is also found in New South Wales and Queensland.

ANNUAL REPORT OF THE COUNCIL

FOR THE YEAR 1921

The Council herewith presents to Members of the Society the Annual Report and Statement of Receipts and Expenditure for the past year

The following meetings were held —

March 10—Annual Meeting

The following office bearers retired by effluxion of time President, Professor Ewart, D Sc , Vice Presidents, F Wisewould, Professor Laby, Hon Treasurer, W A Hartnell Hon Librarian, ———, Hon Secretary, J A Kershaw Members of Council, Professor Osborne, Dr Summers, Dr Baldwin, Messrs Dunn, Richardson, Picken

The following were elected President Professor Ewart, D Sc , Vice Presidents F Wisewould, Professor Laby, Hon Treasurer W A Hartnell, Hon Librarian, A S Kenyon, Hon Secretary J A Kershaw Members of Council Professor Osborne, Dr Summers, Dr Baldwin, Messrs Dunn, Richardson, Picken

The Annual Report of the Council and Financial Statement were read and adopted

At the close of the annual meeting an ordinary meeting was held The following paper was read (1) Blood and Shade Divisions of Australian Tribes,' by Sir Baldwin Spencer, K C M G, F R S, D Sc Exhibit Extracts from Mach s Science of Mechanics,' as bearing upon the Theory of Relativity, by Mr D K Picken Dr J M Lewis was elected a member

April 14th —Paper 'The Age of the Ironstone Beds of the Mornington Peninsula, by Frederick Chapman A L S Professor W E Agar delivered a lecture on "Physical Basis of Heredity"

Mr Studley Miller and Captain Edward Kidson O B E , M Sc , were elected members, Captain R E Trebilcock M C , a coun-

try member; and Dr. Gwynneth Buchanan, Mr. Aubrey Reader, and Mr. Alister Burns, associates.

May 12th:—Papers: (1) "The Australian Species of Carex in the National Herbarium, Victoria," by J. R. Tovey; (2) "Notes on Amycterides, with Descriptions of New Species," Part III., by Eustace W. Ferguson, M.B., Ch.M.; (3) "The Specific Name of the Australian Aturia and Its Distribution," by Frederick Chapman, A.L.S.

Mr. Howard R. Archer, B.Sc. was elected an associate.

July 9th:—Paper: "New Australian Coleoptera, with Notes on Some Previously Described Species," Part I., by F. Erasmus Wilson (communicated by J. A. Kershaw). A lecture was delivered by Professor Orme Masson on "The Structure of the Atom."

July 14th:—Papers: (1) "An Intercomparison of Important Standard Yard Measures," by J. M. Baldwin, M.A., D.Sc.; (2) "The Petrology of the Ordovician Sediments of the Bendigo District," by J. A. Dunn, B.Sc. (Howitt Natural History Research Scholar in Geology); (3) "On an Inclusion of Ordovician Sandstone in the Granite of Big Hill, South of Bendigo," by J. A. Dunn, B.Sc. (Howitt Natural History Research Scholar in Geology); (4) "The Euclidean Geometry of Angle," by D. K. Picken, M.A.

Messrs. F. E. Wilson, J. Cronin, and N. Rosenthal were elected associates.

August 11th:—Paper: "An Alphabetical List of Victorian Eucalypts," by J. H. Maiden, I.S.O., F.R.S., F.L.S. A lecture on "The Development of Horticultural Varieties of Various Plants," was given by Mr. J. Cronin. A series of botanical specimens were exhibited to illustrate the lecture.

Mr. Stanley S. Addison was elected a member.

September 8th:—Papers: (1) "The Rotifera of Australia and Their Distribution," by J. Shephard; (2) "Local Rain Producing Influences in South Australia," by E. T. Quayle, B.A.; (3) "On a New Type of Barometer," by T. H. Laby, M.A.; (4) "On a Gravity Metre," by T. H. Laby, M.A. Mr. F. Chapman delivered a lecture on "The Importance of Fossils in Regard to Oil-Finding in Australia." The lecture was illustrated by a series of lantern slides. Exhibits: Professor T. H. Laby showed, (1) "Standard Nickel Metre, which has been

compared with the International Prototype Metre;" and (2) "A Set of Slip Gauges."

October 13th:—Paper: "Development of Endosperms in Cereals," by M. Gordon, B.Sc. Mr. J. A. Smith delivered a lecture on "Genesis of Energy," illustrated by lantern slides and exhibits. Mr. E. T. Quayle, B.A., was elected a member.

November 10th:—Papers: (1) "Present and Probable Distribution of Wheat, Sheep and Cattle in Australia," by G. Thomas, B.Ag.Sc. (communicated by A. E. V. Richardson, M.A., B.Sc.); (2) "Additions and Alterations to the Catalogue of Victorian Marine Mollusca," by J. H. Gatliff and C. J. Gabriel; (3) "Gold Specimens from Bendigo, and Their Probable Modes of Origin," by F. L. Stillwell, D.Sc.; (4) "On a Fossil Filamentous Alga and Sponge-Spicules Forming Opal Nodules at Richmond River, New South Wales," by Frederick Chapman, A.L.S. Exhibit: "Variation in Some Fossil Species," by F. Chapman.

December 8th:—Messrs. J. E. Gilbert and A. E. V. Richardson, M.A., B.Sc., were elected Honorary Auditors. Papers: (1) "On the Changes of Volume in a Mixture of Dry Seeds and Water," by Alfred J. Ewart, D.Sc., Ph.D., F.L.S.; (2) "Further Researches into the Serological Diagnosis of Pleuro-Pneumonia of Cattle," by G. G. Heslop, M.V.Sc., D.V.H., (3) "The High Frequency K Series Emission Spectra of Platinum," by J. S. Rogers, B.A., B.Sc; (4) "The High Frequency K Series Emission Spectra of Tantalum," by H. C. J. Asche, B.C.E., B.Sc.; (5) "Separation of Mercury into Fractions of Different Densities," by W. G. Mepham, B.Sc.; (6) "The Mechanical Equivalent of Heat: Preliminary Determinations," by T. H. Laby, M.A., Sc.D., F.Inst.P., and E. O. Hercus, M.Sc.; (7) "Contributions from the National Herbarium of Victoria, No. 1," by J. R. Tovey and P. F. Morris (communicated by W. Laidlaw, B.Sc.).

Exhibit: Mr. J. A. Kershaw, on behalf of the National Museum, showed a meteorite from the Roper River, N. Territory. The specimen, which weighs about 14 lbs., was found by an aborigine in open forest country, while mustering cattle.

During the year five members, one country member, and seven associates were elected, including one associate elected as a member.

The Council regrets to record the loss by death of Mr M O Copland B M E of the Ballarat School of Mines and Captain Kenneth Aubrey Mickle D S O

Maurice Osric Copland who died August 1st 1920 was a Country Member of this Society having been elected in 1917 At the time of his decease he was Principal of the Ballarat School of Mines He was a native of Victoria educated at Wesley College and graduated B M E at Melbourne University He had a varied experience in Victoria South Africa, Queensland and Western Australia In South Africa he was Petrologist under Dr Hatch and was also engaged in work connected with gold coal and diamond mining in that country His breakdown in health was attributed to his whole hearted zeal in working out repatriation and vocational training schemes after the war whilst at Ballarat Mr Copland left behind a remarkably good record of unselfish work in his particular sphere and much of the success of the research on the white earthenware industry is due to him the Bureau of Science and Industry at his suggestion providing a scholarship for the investigation of this subject

In 1905 Mr Copland published a bulletin on the Monazite Deposit of the Borang District I Gippsland for the Geological Survey of Victoria

Kenneth Aubrey Mickle (Capt) D S O died on 30th July 1919 at 30 Marine Parade St Kilda after a long illness from the effects of gas received in action in France Capt Mickle was the son of Clara and the late David Mickle and was 33 years of age He was educated at Queen s College and after qualifying as a metallurgist conducted research work at Melbourne University for three years There he won the Grimwade prize and other distinctions On the outbreak of war he was chief chemist at the Burma Mines Ltd Upper Burma He enlisted in England in the Royal Garrison Artillery and received a commission being promoted to captain for bravery in the field He had command of the 9th Division Trench Mortar Brigade and was decorated with the Distinguished Service Order He saw much fighting on the Somme and at Arras He was an Associate of our Society His death cut short an exceptionally promising career and he leaves many friends to mourn their loss

The interest in the work of the Society is evidenced by the satisfactory attendances at the usual monthly meetings. The papers submitted were well up to the usual standard, and the subjects dealt with covered a wide field of research.

The attendances at the Council meetings were as follow:—Professor Ewart, 9; Professor Skeats, 9; Dr. Summers, 9; Mr. Richardson, 9; Mr. Kershaw, 9; Dr. Baldwin, 8; Mr. Wisewould, 8; Mr. Chapman, 8; Mr. Shephard, 7; Mr. Dunn, 7; Professor Agar, 5; Professor Osborne, 5; Dr. Green, 5; Professor Laby, 3; *Mr. Hartnell, 3; Mr. Picken, 3; *Mr. Herman, 2; Mr. Kenyon, 2.

Owing to serious illness, Mr. Hartnell, who has occupied the position of Hon. Treasurer continuously for the past thirteen years, was compelled to relinquish the duties of the position, which Mr. Shephard kindly undertook to carry on for the remainder of the year. Mr. Hartnell has taken a very keen interest in the work of the Society, and carried out the duties of Treasurer in a particularly conscientious manner. His resignation was received with great regret, and the Council's appreciation of his valued services has been placed on record.

The Librarian reports that 1463 volumes and parts were added to the Library during the year. The work of revising the card catalogue has been continued, and by a re-arrangement of the books on the shelves an appreciable amount of space has been gained. It is to be regretted that want of funds will not allow of much necessary binding.

Volume XXXIII. of the Proceedings was issued on the 9th May, and Part I of Volume XXXIV. on the 31st October. Part II. of the same Volume is now well advanced, and should be available for issue at an early date.

During the year the delivery of short popular lectures on subjects of general interest was continued. These were given by Professor W. E. Agar, Professor Orme Masson, and Messrs. J. Cronin, F. Chapman, and J. A. Smith, and were well attended.

* Absent on leave and through illness

Financial Statement for the year ending 28th February, 1922

RECEIPTS

Balance at 1st February, 1921				£95	13	0
Subscriptions—						
Members	£144	18	0			
Associates and Country Members	95	7	6			
				240	5	6
Rents—						
Com'wealth Government	£25	0	0			
Field Naturalists' Club	12	0	0			
				37	0	0
Sales of Publications				1	1	0
Victorian State Government Grant in Aid				100	0	0
Drawn for Distribution and Unexpended				4	10	0
				£478	9	6

EXPENDITURE

Publication—						
Printing	£278	7	6			
Distribution	38	10	0			
				£316	17	6
Maintenance—						
Assistant Secretary	£30	0	0			
Assistant Librarian	12	0	0			
Caretaker's A/cs	19	1	2			
Rates	7	13	8			
Repairs	9	13	9			
Insurance	5	1	3			
Petty Cash	6	0	0			
Sundries—Gas, Electric Light, etc	6	0	4			
				95	10	2
Cash Charges—						
Commission	25	11	6			
Cheque Book	1	0	0			
				26	11	6
Library				8	2	6
Balance at 28th Feb 1922				31	7	10
				£478	9	6

J SHEPHARD, *Acting Hon Treas*

We have examined Pass Books and hereby certify that all amounts entered herein have been paid to the credit of the Society We have seen receipts for all payments

JAMES E GILBERT, } *Hon*
A E V RICHARDSON, } *Auditors*

7/3/22

N B.—Liability for printing has been incurred estimated at £187

Royal Society of Victoria.

1921.

Patron.

HIS EXCELLENCY THE RIGHT HON. THE EARL OF STRADBROKE, K.C.M.G., C.B., C.V.O., C.B.E.

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J. M. BALDWIN, D.Sc.

11A

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J SHEPHARD.

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1921.

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WITH THEIR YEAR OF JOINING

[Members and Associates are requested to send immediate notice of any change of address to the Hon Secretary]

PATRON

His Excellency The Right Hon The Earl of Stradbroke

HONORARY MEMBERS

Liversidge, Professor A , LL D F R S , "Fieldhead ' George road Coombe Warren, Kingston, Surrey, England	1892
Verbeek, Dr R D M , Speelmanstraat, 19, s'Gravenhage, Holland	1886

LIFE MEMBERS

Fowler, Thos W , M C E Duncan's road, via Werribee	1879
Gilbert, J E , 13 Edward street, Kew Vic	1872
Gregory, Prof J W , D Sc F R S F G S , University, Glasgow	1900
Love, E F J, M A, D Sc, F R A S, Moreland Grove, Moreland	1888
Selby, G W , "Lindisfarne" Scott-grove, E Malvern	1881
Smith, W Howard, ' Moreton," Esplanade, St Kilda	1911
Sticht, Rt , B Sc , M Am Inst M E , Mt Lyell Mine, Queenstown, Tasmania	1913

ORDINARY MEMBERS

Addison, Stanley, University, Melbourne	1921
Agar, Prof W E , F R S , M A , D Sc , University Melbourne	1920
Baker, Thomas Bond street, Abbotsford	1889
Bale, W M , F R M S Walpole street Kew	1887

Baldwin, J M, D Sc, Observatory, South Yarra	1915
Balfour, Lewis, B A, M.B., B S, Burwood-road, Hawthorn.	1892
Baracchi, Pietro, F R A S, George Hotel, St Kilda	1887
Barrett, A O, 25 Orrong-road, Armadale	1908
Barrett, Sir J W, K B E, C M G, M D, M S, Collins-street Melb	1910
Boys, R D, B A, Public Library, Melb	1903
Brittlebank, C C, "Queensgate," St George's-road, Elsternwick	1898
Chapman, F, A L S, National Museum, Melb	1902
Cudmore, I A, 17 Murphy-street South Yarra	1920
Davis, Captain John King, "Tasma" Parliament-place, Melbourne	1920
Deane, H, M A, M Inst C E, 14 Mercer road, Malvern	1914
Dunn, E. J, F.G S, "Roseneath," Pakington-street, Kew.	1893
Dyason, E C, B Sc, B M E, 60 Queen street, Melb	1913
Ewart, Prof A J, D Sc, Ph D, F L S, University, Melb	1906
Garran, Sir R R, St George's road, Toorak	1914
Gault, E L, M A, M B, B S, Collins street, Melb	1899
Gilruth, J A, D V Sc, M R C V S, F R S E, 520 Munro street, South Yarra	1909
Goodwin, W W, Esq Commonwealth Lands and Survey Branch, Melbourne	1920
Gray, Wm, M A, B Sc, Presbyterian Ladies' College, East Melb	1913
Green W Heber, D Sc University, Melbourne	1896
Grimwade, W Russell, B Sc, 335 Spencer-street, Melb	1912
Grut, P de Jersey, F R Met S, 103 Mathoura-road, Toorak	1869
Hartnell, W A, Burke-road, Camberwell	1900
Herman, H, B C E, M M E, F G S, "Albany," 8 Redan-street, St Kilda	1897
Higgin, A J, F I C, University, Melb	1912
Horne, Dr G, Lister House, Collins-street, Melbourne	1919
Kendall, W T, D.V Sc, M R C V S, 36 Park-street, Brunswick, Vic	1911
Kenyon, A S, C E, Lower Plenty-road, Heidelberg	1901

Kelly Bowes Glenferrie-road Malvern 1919
Kernot W N B C E University Melb 1906
Kershaw J A F E S National Museum Melb 1900
Kidson E O B E M S Meteorological Bureau Melb 1921

Laby Prof T H M A Sc D F Inst P University Melb 1915
Laidlaw W B Sc Department of Agriculture Melb 1911
Lewis J M D D Sc Whiteth rn Boundary road Burwood 1921
Littlejohn W S M A Scotch College Melb 1920
Lyle Prof T R M A D Sc F R S Irving road Toorak 1889
Loughrey B M A M B B S M C E 1 Elgin street Hawthorn 1880

Mackay A D M M E B Sc 4 Fawkner street South Yarra 1920
MacKenzie Colin W M D B S F R C S 88 Collins street Melb 1910
McPherson Hon H r W M M L A Coppin grove St James Park Hawthorn 1913
Mahony D J M Sc Lister House Collins street Melb 1904
Masson Prof Orme M A D Sc F R S E F R S University Melb 1887
Merfield C J Observatory South Yarra 1913
Michell J H M A F R S 52 Prospect Hill road Camberwell 1900
Miller Hon J D Batman House 103 William street Melb 1920
Miller Leo Melbourne Mansions Collins street Melb 1920
Miller E Studley Glynn Kooyong road Malvern 1921
Monash Lieutenant General Sir John G C B M C E B A LL B 360 Collins street Melb 1913

Nanson Prof E J M A University Melb 1875

Oliver C E M C E Metropolitan Board of Works Spencer street Melb 1878

Osborne Prof W A M B B Ch D Sc University Melb 1910
Owen W J Gaergybi 935 Rathdown street Nth Carlton 1919

Payne, A T Scotsburn Toorak 1911
Payne Prof H M Inst C E M I M E University Melb 1910
Picken D K M A Ormond College Parkville 1916
Pratt Ambrose M A 376 Flinders lane Melb 1918

Quayle E T B A Meteorological Bureau Melb 1920

Richardson A E V M A B Sc Agricultural Department, Melb 1912

Schlapp H H 31 Queen street Melb 1906
Shephard John Norwood South road Brighton Beach 1894
Skeats Prof E W D Sc A R C S F G S University Melb 1905
Spencer Prof Sir W Baldwin K C M G M A D Sc F R S Darley Upper Fern Tree Gully 1887
Summers Associate Prof H S D Sc University Melb 1902
Sutton Harvey M D B S Dept Public Instruction Sydney N S W 1913
Sweet Associate Prof Georgina D Sc University Carlton 1906
Swinburne Hon G M Inst C E M Inst M E Shenton Kinkora road Hawthorn 1905
Syme G A M B M S F R C S 1J Collins street Melb 1913
Syme Geoffrey Banool Studley Park road Kew 1913

Taylor R 31 Queen street Melb 1907
Taylor Assoc Prof Griffith B A B E D Sc University Sydney N S W 1918
Thom L N B Sc Patent Office Melbourne 1910

Walcott R H Technological Museum Melb 1897
Wisewould F 408 Collins street Melb 1902
Woodruff Prof H A M R C S L R C P M R C V S Veterinary School University Melb 1913

Country Members

Allen, G M, F R M S, Stribling's Buildings, Euroa 1913
Armitage, R W, M Sc, F G S, F R G S, 95 Foam Street, Elwood 1907

Bowclay, W, "Rawson" 34 Newcastle street, Rose Bay, Sydney, N S W 1919

Collyer, W J, M Sc 115 Raglan street, Ballarat 1919
Crawford, W Gisborne 1920

Dare, J H, B Sc, Elementary High School Warracknabeal 1917
Drevermann J, Longerenong Agricultural College Dooen 1914

Easton, J G, Geological Survey Corryong 1913

Ferguson, E W M B Ch M "Timbrebongie," Gordon-road, Roseville Sydney, N S W 1913

Harris, W J, B A, High School, Kyneton 1914
Hogg, H R, 7 St Helen's Place, London, E C
Hope, G B, B M E, Gordon Technical College, Geelong 1918

James, A B A, B Sc High School, St Arnaud 1917

Kewish, P D, B A, B Sc, Commonwealth Transcontinental Railway, South Australia 1919
Kitson A E, F G S 109 Worple-road, Wimbledon, London S W, England 1894

Langford W G, M Sc, B M E, Vailala Oilfields, Papua 1918
Lea, A M, F E S, Museum, Adelaide, S A 1909

Richards, Prof H C D Sc, University, Brisbane, Queensland 1909
Roberts, J K Cavendish Laboratory, Cambridge, England 1919

Trebilcock, Captain, R E, M C, Wellington street, Kerang 1921

Whitelaw, H S, Geological Survey Office, Bendigo. 1914

Corresponding Members

Dendy, Professor Arthur, D Sc, F R S, Sec L S., King's College, London 1888

Lucas, A H. S, M A, B Sc, Sydney Grammar School, Sydney, N S W. 1895

Merrel, F P, Rhodesian Museum, Buluwayo, South Africa 1919

Associates

Allen, Miss N C B, B Sc, Physics Dept, University, Melb 1918

Archer, Miss E M Sc, 140 Park street, Parkville 1917

Archer, Howard R B Sc, Geology School, University 1921

Ashton, H, "The Sun," Castlereagh street, Sydney, N S W 1911

Bage, Mrs Edward, "Cranford," Fulton street, St Kilda, 1906

Bage Miss F, M Sc, Women's College, Kangaroo Point, Brisbane, Queensland 1906

Baker, F H, 167 Hoddle-street, Richmond 1911

Barkley, H Meteorological Bureau Melb 1910

Bordeaux, E F J, G M V C B ésL, 427 Mount Alexander-road, Moonee Ponds 1913

Brake J B Sc, Yering 1913

Breidahl, H, M Sc, M B, B S 36 Rouse-street Port Melb 1911

Brodribb, N K S, Cordite Factory, Maribyrnong 1911

Bryce, Miss L M, B Sc, Biology School University, Melb 1918

Buchanan, G, D Sc, University, Melb 1921

Burns A c/o Miss Stirling, "Roslyn," Salisbury road, Rose Bay, Sydney N S Wales 1921

Carton, M, M A, University, Melb 1913

Chapple, Rev E H, The Manse, Warrigal road Oakleigh 1919

Clendinnen, F W J, "Haven," Hawksburn 1918

Clinton, H F Produce Office, 605 Flinders street, Melb 1920

Cook, G, M Sc, B M, Elphin-grove, Hawthorn 1919

Cookson, Miss I C, B Sc 154 Power street, Hawthorn 1916

Coulson, A L, M Sc, "Finchley," King street, Elsternwick 1919
Crespin, Miss R, Geology School, University, Melb 1919
Cronin, J, Botanical Gardens, South Yarra 1921

Danks, A T, 391 Bourke-street West, Melb 1883

Fenner, C A, D Sc, Education Department, Flinders-street, Adelaide, S A 1913
Fenton, J J, 20 Northcote road Armadale 1910
Ferguson, W H, 37 Brinsley-road, E Camberwell 1894
Finney, W H, 40 Merton street, Albert Park 1881

Gabriel, C J, 293 Victoria street Abbotsford 1908
Gatliff, J H, 5 Fawkner street, S Yarra 1898
Gordon Miss M B Sc Botany School University, Melb 1919

Hardy, A D, F L S, Forest Department, Melb 1903
Hart, T S, M A, B C E, F G S, Scoresby 1894
Hauser H B B Sc Geology School University, Melb 1919
Hoadley, C A M Sc B M E c/o Richardson Gears, Footscray 1910
Holmes, W M, M A, B Sc, University, Melb 1913
Howitt, A M, Department of Mines, Melb 1910
Hunter, Stanley B Department of Mines, Melb 1908

Jack, A K, M Sc, "Kilkerran," Williams street, Brighton 1913
Jobbins, G G, Electric Lighting and Traction Co, Geelong 1902
Jona, J Leon, M D, B S, D Sc, 16 Collins street Melb 1914
Junner, N, M Sc M C, Gold Coast Geol Survey, London 1912
Jutson, J T, B Sc, "Oakworth," 2 Austin avenue, St Kilda 1902

Keartland, Miss B, B Sc, Cramer street, Preston 1919
Keble, R A, Department of Mines, Melb 1911

Lambert, C A, Bank of N S W, Melbourne 1919
Luber, R. E, B A, 101 Hickford street, E Brunswick 1919
Luly, W H, Department of Lands, Public Offices, Melb 1896

McInerney, Miss K , M Sc , Geology School, University, Melb 1918
Macdonald, B , Meteorological Bureau Melbourne 1920
Mackenzie, G , 1 High-street, Prahran 1907
Maclean, C W , "Devon," Merton avenue, Elsternwick 1879
Malcolm, L W G , c/o Royal Colonial Institute, Northumberland-avenue, London, W
McLennan, Ethel, D Sc , Botany School, University, Melb 1915
Melhuish, T D A , B A , Port Pirie, South Australia 1919
Mollison, Miss E , M Sc , Royal Crescent, Camberwell 1915
Montgomery, J N , Upoia Oilfield, Papua 1912
Moore, F E , M B E , 4 Mont Albert road West, East Kew 1920
Morris M , M Sc , Langwarrin 1912

Nicholson, Miss Margaret G , 59 Murray street, Elsternwick 1920

O'Neill, W J , Lands Dept , Melb 1903
Osborne, Miss A , B Sc , Biology School University, Melb 1918

Patton, R T, B S. M F, Biology School, University, Melb
Pern, Dr Sydney, 16 Collins street, Melb 1920
Peterson, Miss K , B Sc , Biology School, University, Melb 1919
Piesse, E L , Prime Minister's Dept , Melb 1921

Raff, Miss J , M Sc , University, Melb 1910
Reader, Aubrey, Koornang road, Carnegie 1921
Ritchie, E G , M Inst C E , Met Board of Works, Spencer street, Melb 1909
Rivett, Assoc Prof A C D , M A , D Sc , University, Melb 1914
Rosenthal, Newman H , 427 Cardigan street, Carlton 1921
Rossiter, Captain A L , M Sc , University, Melb 1913
Rossiter, Mrs A L , M Sc , University, Melb 1911

Scott, T F , M A , High School, Warragul 1917
Sharman, P J , M Sc , "Glenalvie," 9 Daphne-street, Canterbury 1916

Singleton, F A, M Sc, Geology School University, Melb	1917
Smith, J. A, 15 Collins-place, Melb	1905
Stickland, W, Thomas-street, Black Rock	1914
Stillman, Miss G, Botany School, University Melb	1919
Stillwell, F L, D Sc, 44 Elphin grove Hawthorn	1910
Sutton, C S, M B, B S, Rathdown street, N Carlton	1908
Teale, E O, D Sc, F G S, F R G S "Coleraines," 34 Plough lane, Lutlev, Surrey, England	1898
Thorn, Wm, Mines Department, Melb	1907
Tovell, C M, M Sc, Scotch College, Launceston, Tas	1913
Traill, J C, B A, B C E, 630 St Kilda-road	1903
Trudinger, W, Gerald-street, Murrumbeena	1918
Weatherburn, C E, D Sc, M A, Ormond College, Parkville	1914
Webster, R, M D, "The Eyrie," Eaglemont, Heidelberg	1918
White, R A, B Sc, School of Mines Bendigo	1918
Whitelaw, O A L, Geological Survey, Melb	1913
Williamson H B, "The Grange" Corner Waverley road, East Caulfield	1919
Wilson, F E, "Jacana," Darling road E Malvern	1921
Woodward, J H, Queen's Buildings, Rathdown street, Carlton	1903

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The names of new genera and species are printed in italics

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